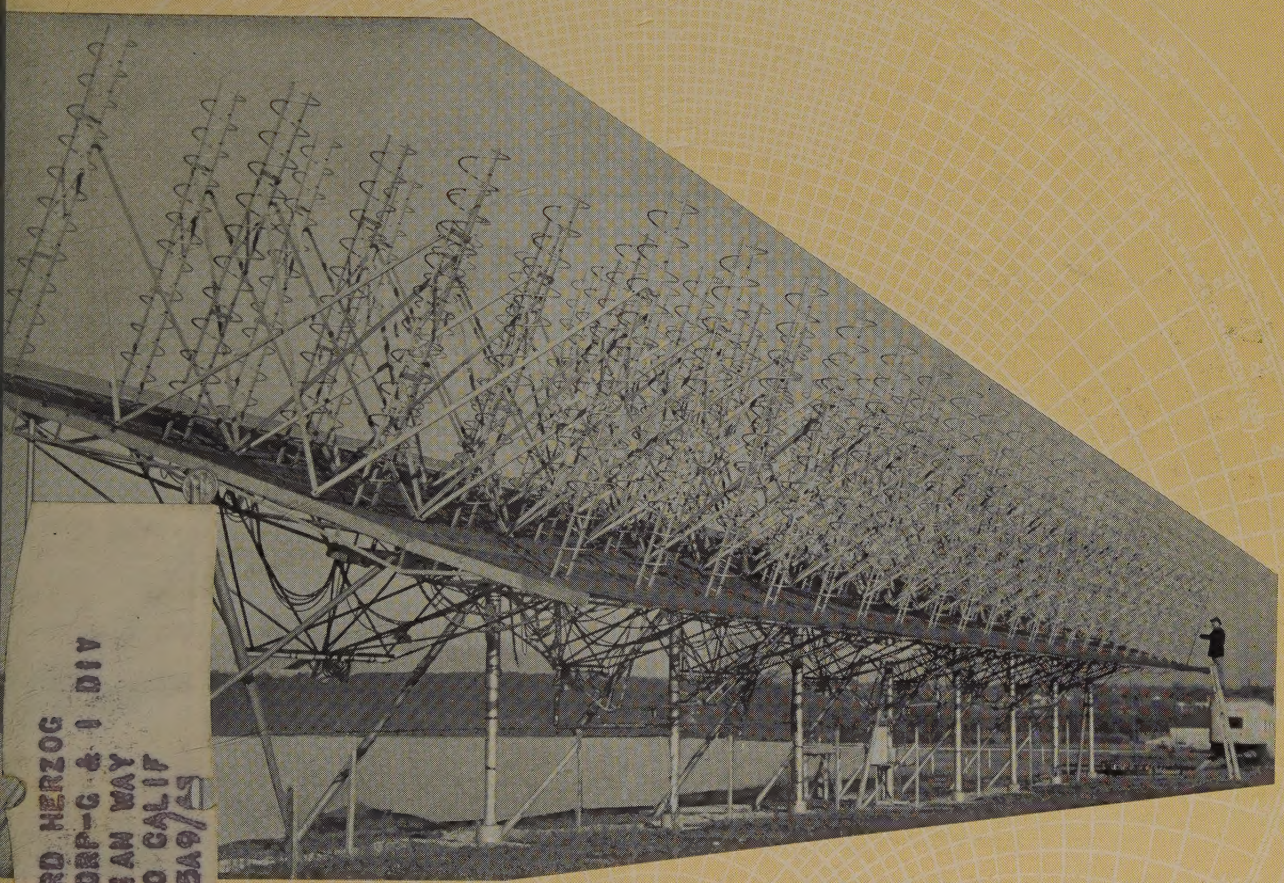
MAY 1960
OLUME 3 • NUMBER 5

- Harrison — Parametric Diode Q Measurements
- Beust & Johnson — High Average Power Rotator
- Harris — Microwave Radiometry — Part II

the microwave journal



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In This Issue . . .

BUSINESS SURVEY: MICROWAVE COMPONENTS MARKET

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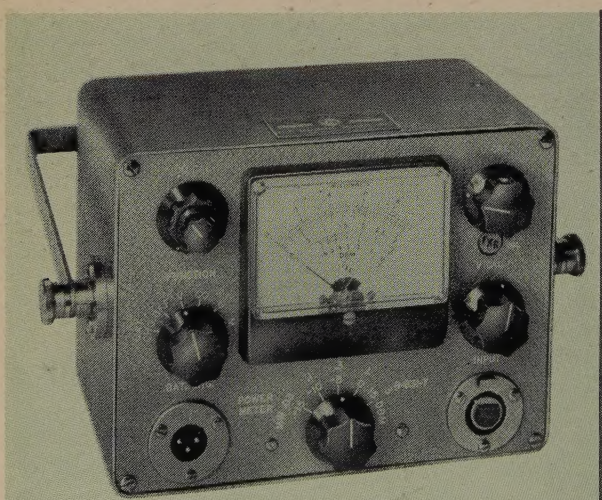

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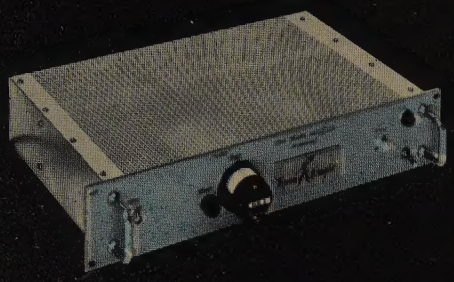
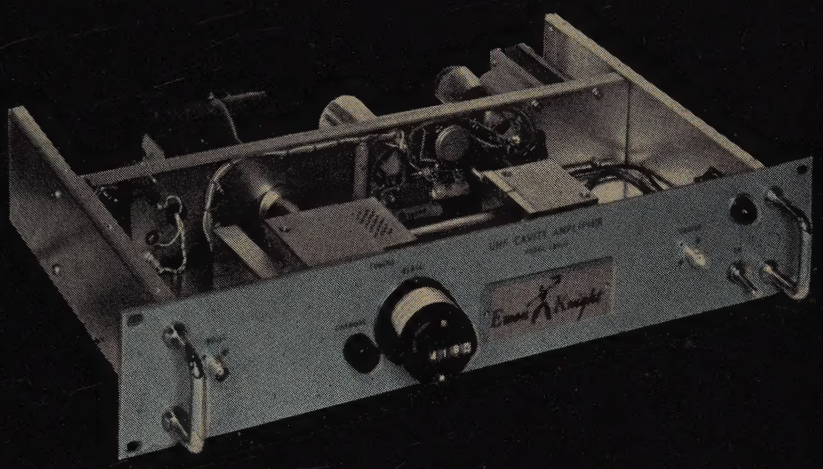
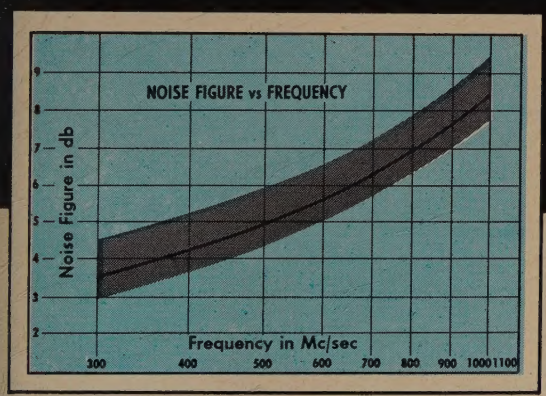


LOW-NOISE UHF CAVITY AMPLIFIER





The Ewen Knight model LNA-T series of amplifiers are ideal for narrow-band applications in the UHF region wherever **low noise is essential.** The four models comprising this series cover the entire frequency range from 300 Mc to 1000 Mc. Rugged, compact and self-contained, each of the LNA-T models mounts on standard 19″ racks and affords easy access to all components, including tube.

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Power:	115 V – 60 CPS

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Model LNA-T4	300 to 450 Mc
LNA-T5	450 to 670 Mc
LNA-T6	500 to 740 Mc
LNA-T8	700 to 1000 Mc

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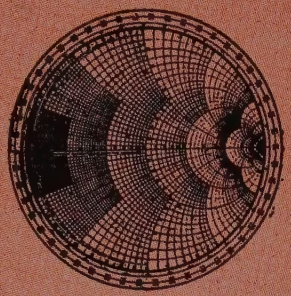
MAY, '60 vol.3 - no.5



the microwave journal

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Microwave Engineering Aspects of Electron Linear Accelerators — Part II

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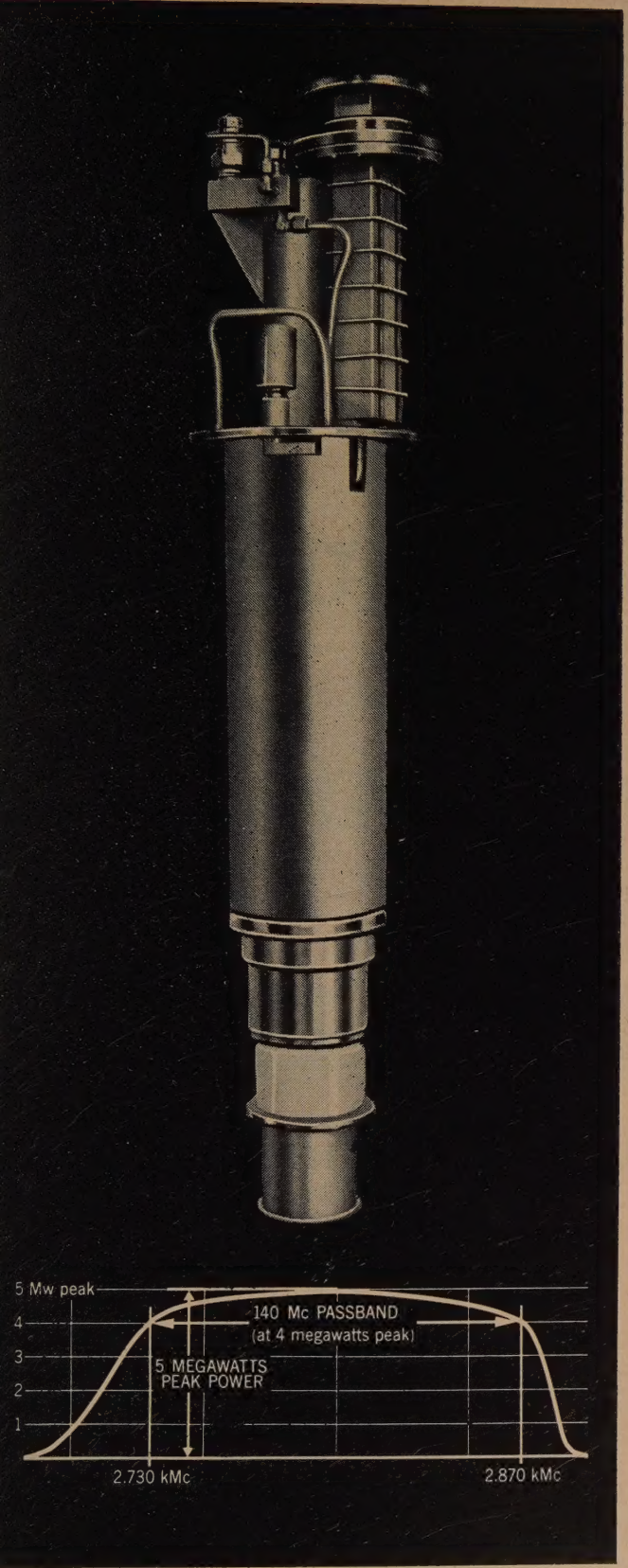

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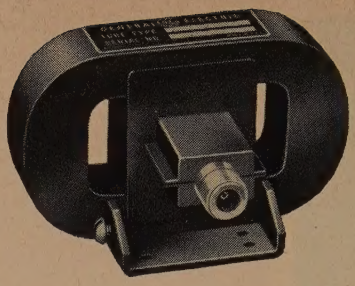
NOW  for L-Band

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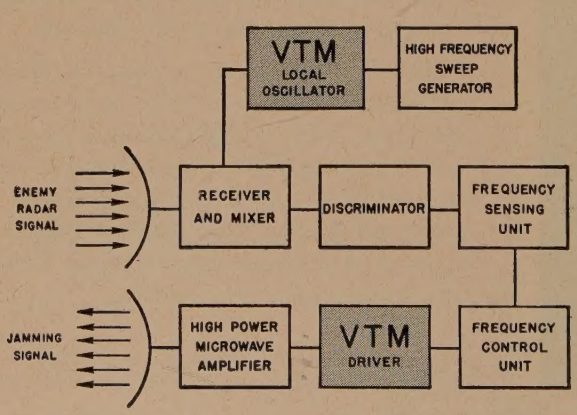
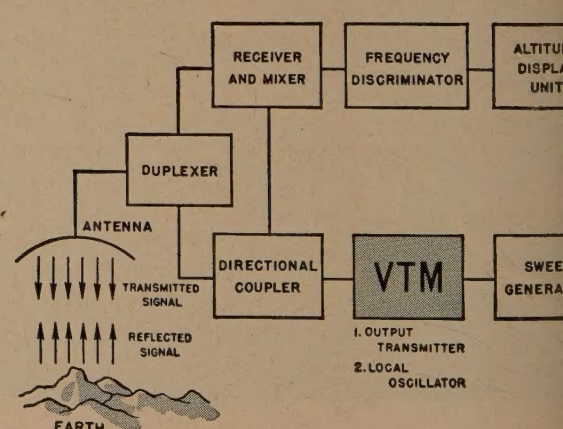


COUNTER-MEASURE SYSTEM



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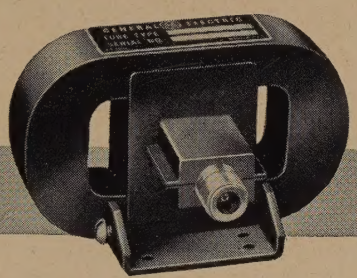

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MICROVIEWS OF THE MONTH

47 ▶ **MICROWAVE RADIOMETRY - Part II**

Donald B. Harris

Knowledge of the universe outside of the earth's atmosphere has been greatly expanded by the use of radio astronomy techniques. This paper deals not with the large field of radio astronomy, but with instrumentation used in this art. Part II, presented in this issue, discusses the instrumentation utilized and summarizes some of the results obtained.

43 ▶ **PARAMETRIC DIODE Q MEASUREMENTS**

Richard I. Harrison

This article presents a theory of varactor Q measurement at microwave frequencies and outlines a method for determining Q when the series resistance begins to deviate from a constant value. Experimental procedure and equipment requirements for the Q measurement are discussed.

55 ▶ **HIGH AVERAGE POWER ROTATOR**

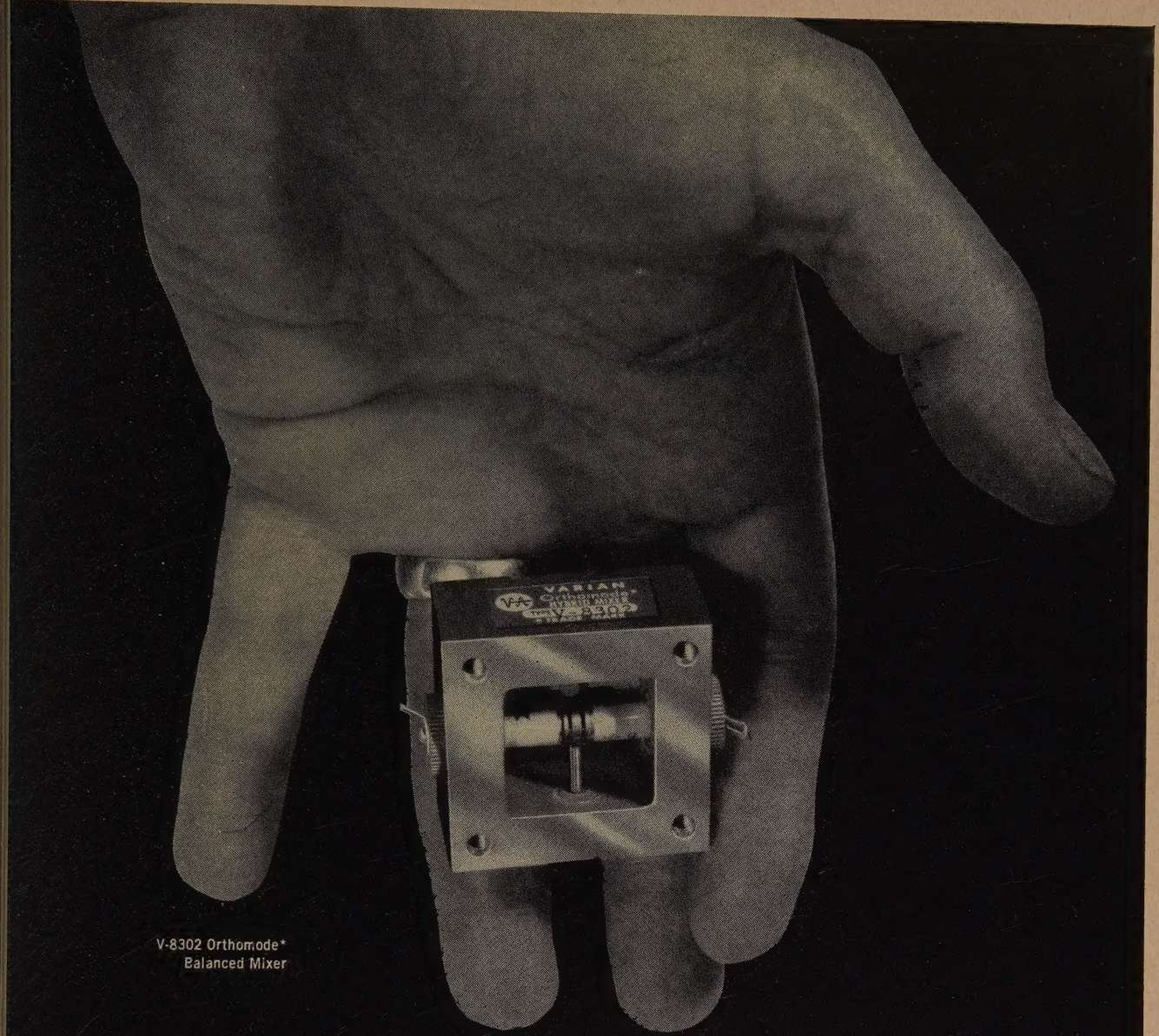
Walter Beust and Edward G. Johnson

The advent of modern high average power tubes accents the importance of dissipating losses occurring in the high power transmission line. The Faraday rotator section in its conventional form of an axially located ferrite pencil, is inherently a poor power dissipating device. By placing the ferrite slabs on the walls of an octagonally shaped rotator section, the dissipative area of the device is increased by a factor of ten, and the electrical performance of the unit remains similar to the conventional axially located ferrite section. The octagonal rotator section is satisfactory for operation at average power levels up to several kilowatts.

OUR COVER

A view of the 96 helix radio telescope at the Ohio State University Radio Observatory, used in obtaining some of the results described in Donald Harris' paper on Microwave Radiometry. See page 47.

Photo courtesy John D. Kraus, Director, The Ohio State University Radio Observatory.



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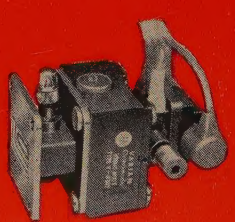

V-8302 Mixer with Varian VA-217S Klystron and Bomac BL-S-504 crystal protector tube.

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Signal Input VSWR <2.0
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I. F. Frequency 20 to 120 mc.

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TOO MANY ADS?

Since its first issue, *the microwave journal* has shown a steady growth in size. Although the technical and editorial portions of the magazine have increased only slightly, the number of advertising pages has increased considerably since the first issue.

Needless to say, we on the staff of *the journal* are pleased, since it signifies increasing acceptance by the industry. But, as it so often happens, every silver lining is surrounded by a cloud. In this case we have heard comments by a few of our readers that the magazine carries too much advertising.

This attitude on the part of a relatively small minority is worth considering.

To begin with, *the microwave journal* is devoted to the microwave industry, for the microwave industry, and by the microwave industry. Our fundamental premise, when we first began, was to have technical quality without compromise. We have adhered to this policy and will continue to do so, regardless of the number of advertisers.

Another basic premise was the fact that our advertisers would be companies in the microwave industry, either as a participant (i.e., component manufacturer, etc.), a contributor (special materials), or a user (systems). Again we can say that we have conformed to this policy.

Another very important and basic consideration is the reams of useful information contained in the advertising, all devoted to our industry. The information is useful to the engineer as well as the purchasing agent.

One thought that does not often occur to the engineer reading one of the so-called "controlled circulation" publications is the simple fact that it is the advertiser who is paying for his subscription. The fact that it comes to him free need not imply that it must be of inferior quality. Actually, many of our better publications are of this type, and strict editorial control is not uncommon.

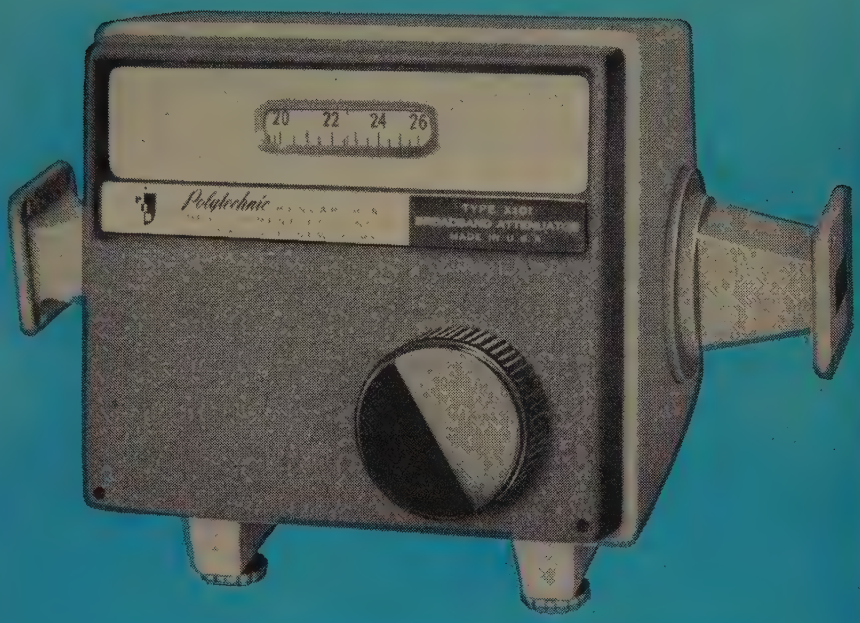
We have commented on many occasions that the microwave industry, or for that matter any growing industry, is not purely technical, not purely business, and certainly not purely social. It takes all these factors, plus more, in proper balance to give the honest picture we must have.

We will continue to publish the very best technical articles available. We will try to keep the technical and editorial section of such a size that it can be digested in a reasonable length of time. We will continue to accept microwave advertisers (Bill Bazzy insisted I put this in) whose advertising pays for your free copy. We will try to be objective in our planning in an effort to present the whole picture of the entire microwave industry.

Our ears will continue to grow in size as we listen for your comments and try to satisfy some of your technical needs and save your time.

Ted Saad

PRD's brand new Broadband Attenuators



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C 101	5.3 — 8.2	0.5 db	14 7/16	6 5/16	7 3/16
H 101	7.05 — 10.0	0.5 db	11⅜	6 5/16	7 3/16
X 101	8.2 — 12.4	0.5 db	9	6⅛	6¼
U 101	12.4 — 18.0	0.7 db	7 11/16	5⅛	6¼
K 101	18.0 — 26.5	0.7 db	7 5/16	5⅛	6¼
A 101	26.5 — 40.0	1.0 db	6 13/16	5⅛	6¼

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ATURES:

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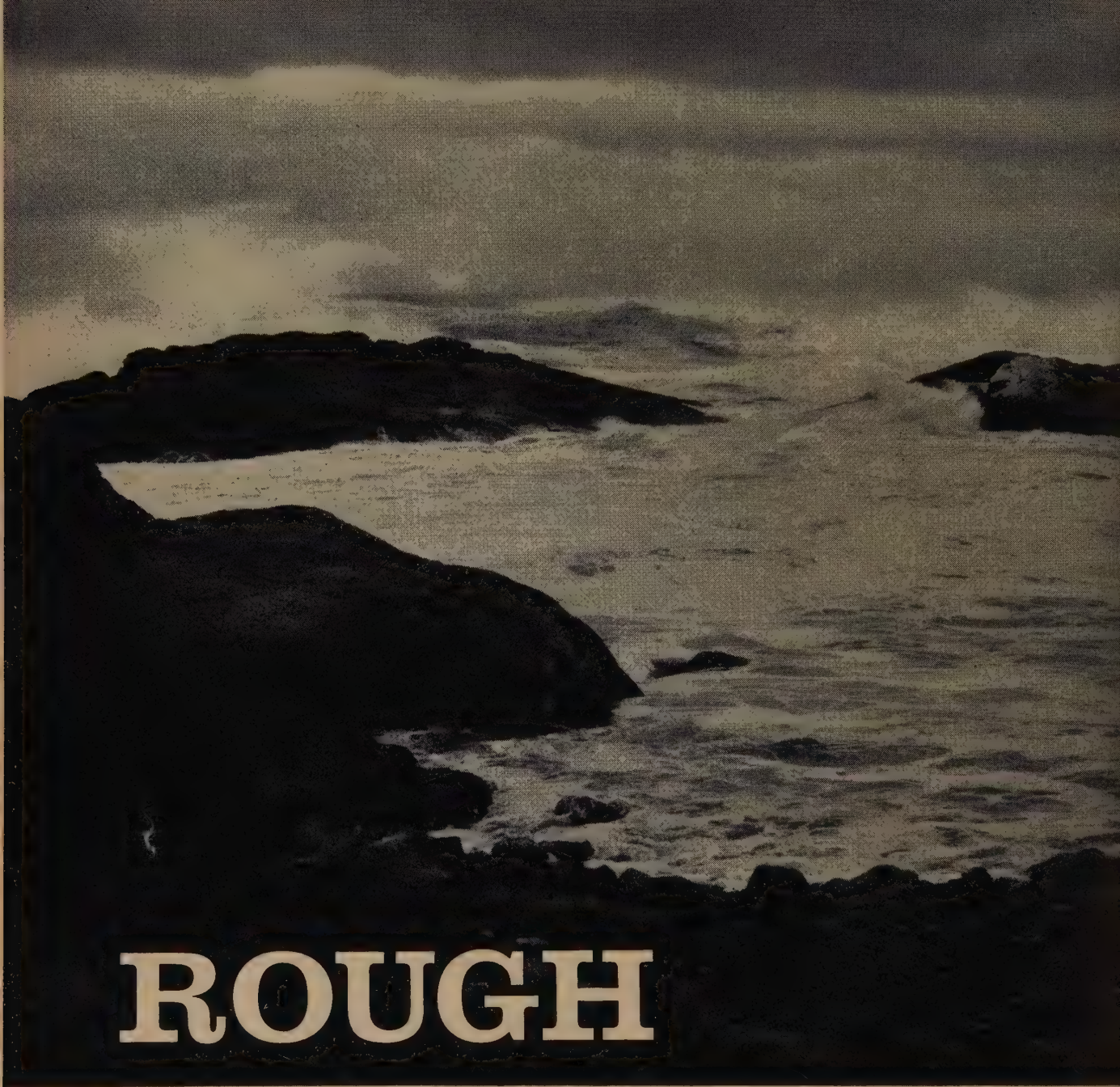
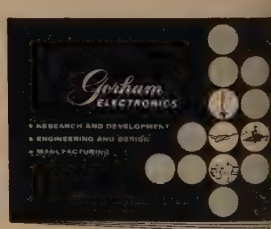


The growing microwave industry constantly generates new and complex problems. And just as constantly, solutions to these rough problems keep springing from the minds of men – like the scientists and engineers who team to provide the integrated microwave design, manufacturing, test and research services of



A few moments reviewing Gorham Electronics' and our wholly owned subsidiary Pickard & Burns, Inc services will be time well invested. Write for your copy of this brochure

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Letter

To the Editor

litor,

e microwave journal

ear Mr. Saad:

I must say that I have rarely seen anying more to the point than your editol in the January 1960 issue.

We also suffer from this problem, and upled with the 'fear of failure' is the sire in the young for absolute security, d to be secure, it has to be played safe the detriment of adventurous progress.

I do not entirely blame the young; any people of my generation (age midrties) are to blame. We hear much out the shortcomings of the younger neration on both sides of the Atlantic and even behind the Curtain!—but I ntend that there is nothing fundamenly wrong with the youngsters. They e as good as we were and, in fact, somenes better; but what is lacking in the est is leadership, and any man who has nvictions and is prepared to stick his ck out, go for something and lead and spire, can get the support and results m his young men.

There is another aspect of the fear uation which is more serious. Men who ve the courage to 'have a go' are reained by managements who are afraid failure, or, in some instances for office litical reasons, frightened of success.

The fear even extends to the writers technical articles. The vast majority technical papers are written on a basis "We did this and that and it worked—art eh?" No mention is made of the l-ups and blind alleys; but from an gineering and scientific point of view "No Road" sign is as important as "This Way." There is even a subtle son for parading the whole history of achievement. It often happens that a n or team pursues a line of attack, runs o trouble, and finally, thoroughly bushed, abandons it—the common oods for trees" situation. However, it is metimes the case that the line of attack fundamentally correct, but has failed e to detail troubles. When the whole ry, including the failure, is published, meone with a fresh mind can see where block was, and then show how the ginal line was correct and better than t finally adopted.

In closing, I can only hope that your ay receives the attention it deserves. I going to circulate it here and I know w that in some quarters it will be reded with distaste.

Best wishes,

E. John Dawes
Plessey Co.,
Ilford, England

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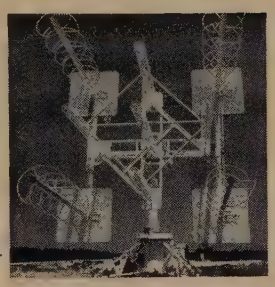
"Hearing" is one of Rantec's best known specialties. In countermeasures, command, communication or telemetry, Rantec is an important supplier to missile and space exploration programs.

HELICAL Through its development of hybrid and other r-f circuitry, Rantec provides the essential elements of many self-tracking telemetry systems. (Illustrated is Rantec's "outboard-inboard" array at Cape Canaveral.)

2D SLOT ARRAYS Rantec produces conical scan, monopulse and other antenna systems for homing and tracking. Rantec has recognized capabilities in scanning antennas by both frequency and ferrite phase shifting methods.



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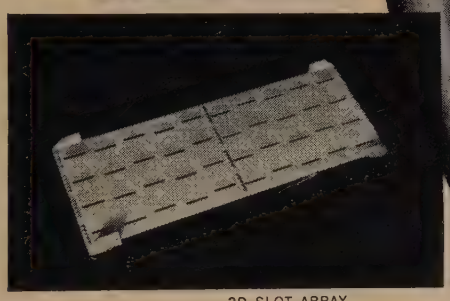
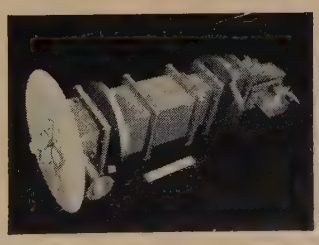


2D SLOT ARRAY



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Constant output level

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Covering the high frequency spectrum, (which includes the 30 and 60 MC radar IF bands) the new hp 606A is exceptionally useful in driving bridges, antennas and filters, and measuring gain, selectivity and image rejection of receivers and IF circuits.

Output is constant within ±1 db over the full frequency range, and is adjustable from +20 dbm (3 volts rms) to —110 dbm (0.1 μv rms). No level adjustments are required during operation.

SPECIFICATIONS

Frequency Range: 50 kc to 65 MC in 6 bands.
Frequency Accuracy: Within ±1%.
Frequency Calibrator: Crystal oscillator provides check points at 100 kc and 1 MC intervals accurate within 0.01% from 0° to 50° C.
RF Output Level: Continuously adjustable from 0.1 μv to 3 volts into a 50 ohm resistive load. Calibration is in volts and dbm (0 dbm is 1 milliwatt).
Output Accuracy: Within ±1 db into 50 ohm resistive load.
Frequency Response: Within ±1 db into 50 ohm resistive load over entire frequency range at any output level setting.
Output Impedance: 50 ohms, SWR less than 1.1:1 at 0.3 v and below.
Spurious Harmonic Output: Less than 8%.
Leakage: Negligible; permits sensitivity measurements to 0.1 μv.
Amplitude Modulation: Continuously adjustable from 0 to 100%.
Internal Modulation: 0 to 100% sinusoidal modulation at 400 cps ±5% or 1000 cps ±5%.
Modulation Bandwidth: Dc to 20 kc maximum.
External Modulation: 0 to 100% sinusoidal modulation dc to 20 kc.
Envelope Distortion: Less than 3% envelope distortion from 0 to 70% modulation at output levels of 1 volt or less.
Spurious FM: Less than 0.0001% or 20 cps, whichever greater.
Spurious AM: Hum and noise sidebands are 70 db below carrier.
Frequency Drift: Less than 0.005% or 5 cps, whichever greater.
Price: (cabinet) $1,200.00. (rack mount) $1,185.00.
Data subject to change without notice. Prices f.o.b. factory.

HEWLETT-PACKARD COMPANY 5023-C PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.
CABLE "HEWPACK" • DAVENPORT 6-7000 • *Field representatives in all principal areas*

hp world's most complete line of signal generators

NDUSTRY NEWS

1960 NEREM CALL FOR PAPERS

Technical papers describing significant ginal contributions—focused on re-rch and development—are invited for sentation at the 1960 Northeast Elec-nics Research and Engineering Meeting EREM) which will be held on No-nber 15, 16, 17, 1960, in the Com-nwealth Armory and the Sheraton-za Hotel, Boston, Mass.

This year's meeting will project a rked departure in technical program mat, scope and size, as well as type number of exhibits. The program feature many invited state-of-the art rial sessions, with related evening rmal discussion periods.

All registrants will receive at the ference, free-of-additional charge, a y of the NEREM RECORD: a printed -page conference report with 600-0 word digests (supported by drawings photographs) of every paper pre-ed at the meeting. Illustrated profiles every NEREM speaker will also be uded in the RECORD.

suggested, but not inclusive list of ect areas for NEREM 1960 is: Anten-Circuit Theory; Components, Pro-tion Techniques and Reliabilty; tronic Computers; Engineering Man-ment; Feedback Control Systems; rmation Theory and Processing; medical Electronics; Microwave De-s; Theory and Techniques Involving ites, Masers, Parametric Amplifiers Ionized Media; Military Electronics uding Inertial, Infrared and Data-dling Systems; Semiconductor Devices Circuits Including Micro-Circuitry Photo Electronic Applications.

o permit the development of well grated technical sessions, speakers are ested to furnish either complete rs or 400-500 word abstracts, in icate, plus 50-word summaries for nce program mailings.

ll material should be mailed on or re July 15, 1960 to the 1960 NEREM ram Chairman:

J. H. Mulligan, Jr.
Department of Electrical Engineering
New York University
New York 53, N.Y.

uthors will be notified of paper ac-ance or rejection by August 15, 1960.

—m w j—

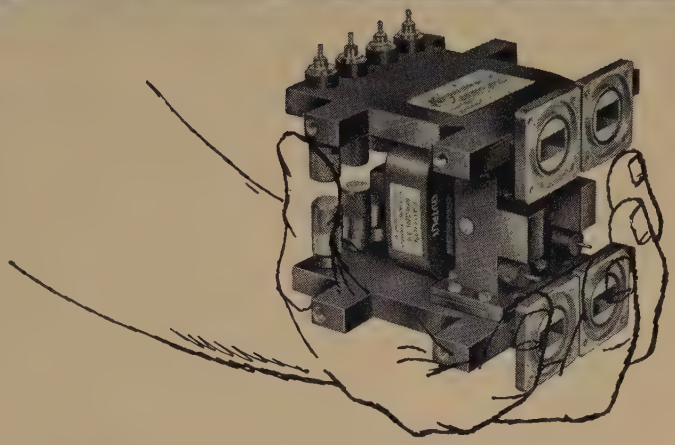
NIPPON ELECTRIC CO. EXECUTIVES VISIT VARIAN ASSOCIATES

ree executives of the Nippon Electric of Tokyo recently visited the Palo , Calif., headquarters facility of an Associates. Nippon is licensed to ufacture Varian designed microwave s for sale in Japan.

oshihide Watanabe, president of Nip-Electric, was accompanied by T. Nara,

(*Continued on page 14*)

PACKAGED PRECISION
for your exact requirements

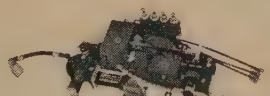


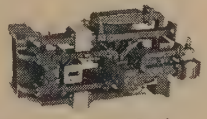
MICROWAVE Kearfott PRODUCTS

MICROWAVE SUB-SYSTEMS

Mono-Pulse Radar

S-Band Strip-transmission Head


Mixer Duplexer


High Power Mixer Duplexer

Kearfott has the experience and ability to design precision sub-systems to the customer's actual configuration and performance needs. The availability of a wide variety of standard components, coupled with advanced techniques, makes it possible to provide packaged r-f assemblies with a high component density—tailored to precise volumetric specifications. For minimum size and weight in airborne or missile applications—for military system environment—Kearfott will successfully design *your* sub-system—to *your* most exacting requirement.

Inquiries may be directed to: 14844 Oxnard Street, Van Nuys, California

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LITTLE FALLS, NEW JERSEY

Circle Reader Service Card 9

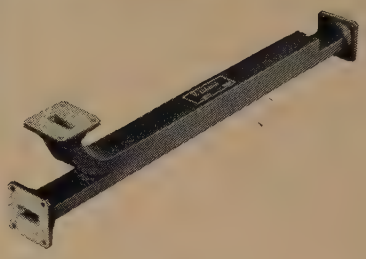
WAVELINE

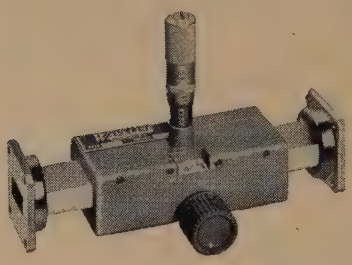
PRECISION MICROWAVE INSTRUMENTS

WR-51 TEST EQUIPMENT

PRECISION COUPLERS
VARIABLE ATTENUATORS
VARIABLE SCREW TUNERS
TERMINATIONS
- HIGH POWER
- LOW POWER
- SLIDING

ADJUSTABLE SHORTS
TRANSITIONS
SHORTING SWITCHES
ELBOWS and TWISTS





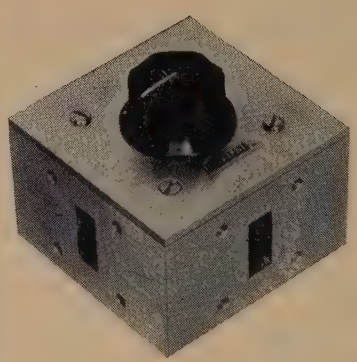
X-BAND WAVEGUIDE SWITCH

Model No. 678-E

This unit is a manually operated four port waveguide switch for use over the full range of 8.2 to 12.4 Kmc. This precision X-band has been designed for laboratory use or for systems application to make alternate connections between two waveguide inputs and two waveguide outputs.

Characteristics:
VSWR of less than 1.05
Isolation greater than 45 db.
Attenuation negligible

An "H" plane version of this switch is also available as Waveline Model No. 678-H.



WAVELINE INC.

CALDWELL, NEW JERSEY

Phone CApital 6-9100 TWX Caldwell, N. J. 703

Industry News

(*Continued from page 13*)

chief, Foreign Liaison Section; and Koheiji Toyama, a section chief of the Export Division, when he toured Varian's microwave tube research laboratories and production facilities.

Nippon Electric Co. is Japan's largest manufacturer of microwave tubes and is particularly known for its extensive line of traveling wave tubes.

Under a second licensing agreement now under discussion, Varian expects to manufacture and sell Nippon microwave tube types that are not included in the Varian product line in the United States.

—*mwj*—

CORNELL APPOINTS SPERRY SCIENTIST 'HONOR PROFESSOR'

Dr. Chao C. Wang, Sperry Gyroscope Company Electronics scientist at Great Neck, N.Y., has been awarded the coveted Victor Emanuel Distinguished Professorship at Cornell University for the Spring 1960 term, it was announced recently by Dale R. Corson, dean of the College of Engineering.

Professor Wang, engineering department head for microwave tube research at Sperry, is the fourth recipient of the academic honor, awarded to "persons of broad technical competence whose interests extend into many fields of science and engineering."

Earlier recipients of the professorship which is sponsored by the Avco Manufacturing Company, were the U. S.'s Dr. Theodore von Karman; Balthazar van der Pol, expert in applied mathematics and Olof E. H. Rydbeck of Sweden, an authority on upper atmosphere physics.

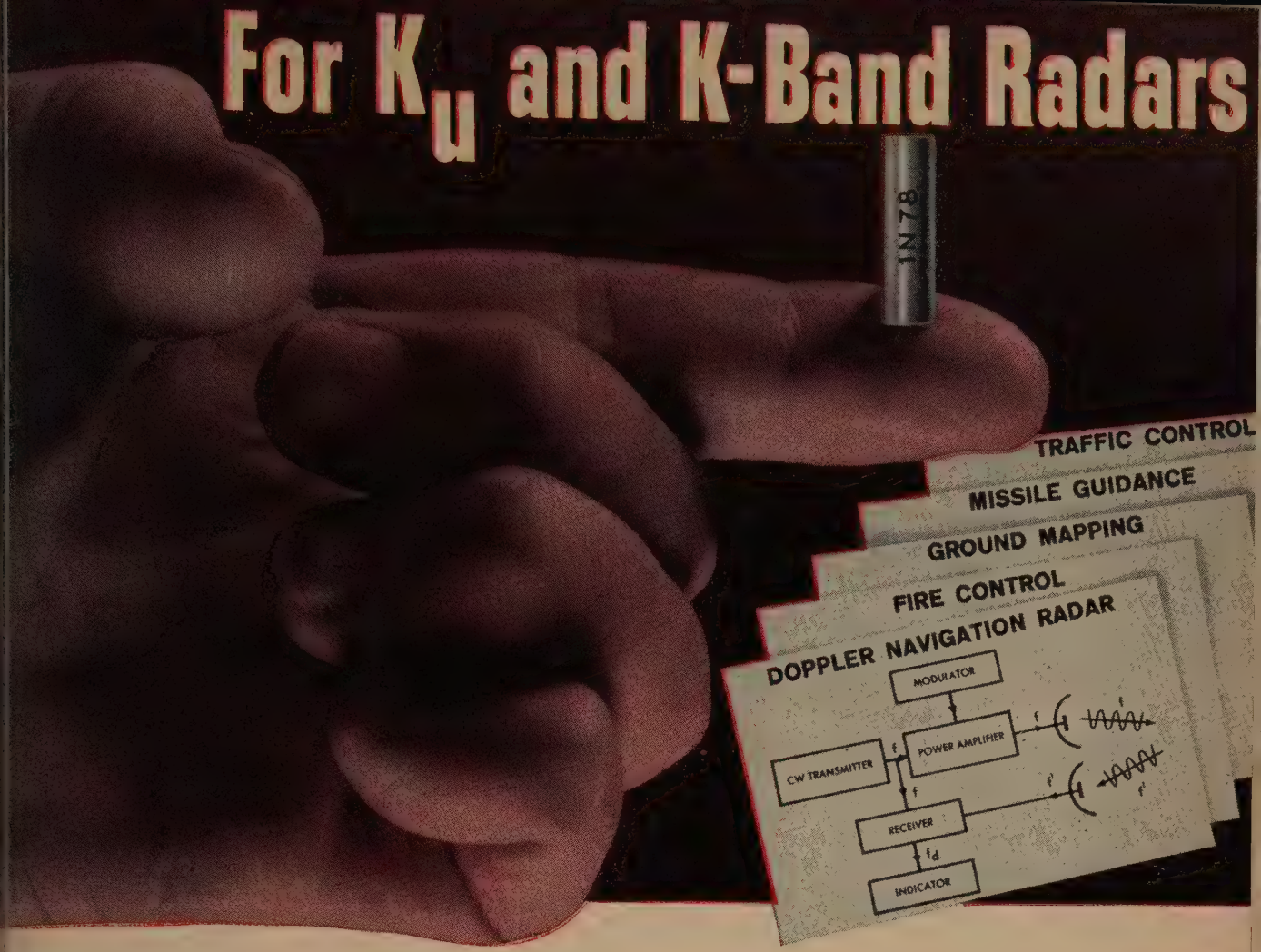
Purpose of the honor is to bring distinguished men "to the Campus chiefly for their ability to stimulate the (Cornell) staff both academically and professionally."

A Sperry research scientist since 1946, Professor Wang is known widely for his many basic contributions in electron physics and the microwave tube field.

(*Continued on page 16*)

Circle Reader Service Card 11

For K_u and K-Band Radars



PHILCO Silicon Mixer Diodes offer PREMIUM FEATURES ... without PREMIUM PRICES

	1N26	1N26A	1N26B	
Conversion Loss	8.5	7.5	7.5	(db)
Noise Ratio	2.5	2.0	1.5	(times)
RF Impedance	—	1.6	1.5	(VSWR)
Over-all Receiver Noise	13.1	11.3	10.0	(db)

	1N78	1N78A	1N78B	1N78C	1N78D	
ɔnversion Loss	7.5	7.0	6.5	6.0	5.7	(db)
ɔise Ratio	2.5	1.5	1.3	1.3	1.3	(times)
F Impedance	—	1.6	1.6	1.5	1.5	(VSWR)
ver-all Receiver ɔise	11.8	9.8	8.8	8.3	7.5	(db)
ırn-Out	0.3	0.3	0.3	0.6	0.6	(ergs)

Philco offers the only complete line of silicon mixer diodes in the 1N26 and 1N78 families that provides *hermetically sealed cases* and *operating temperature ratings up to 150° C* in the entire line. Every Philco diode, from top to bottom of the line, has these important premium features . . . at no additional cost!

Philco Silicon Diodes give highest performance and sensitivity in both the 16,000 mc and 24,000 mc regions. The newest members, 1N26B and 1N78D, offer the lowest over-all noise figures available. If you are designing for maximum performance and reliability, to meet rigid specifications . . . why be satisfied with ordinary diodes, when these premium feature diodes are available at the same prices . . . from Philco. All diodes in these series are available in matched pairs.

For data sheets, write: SPECIAL COMPONENTS DEPARTMENT MJ-560

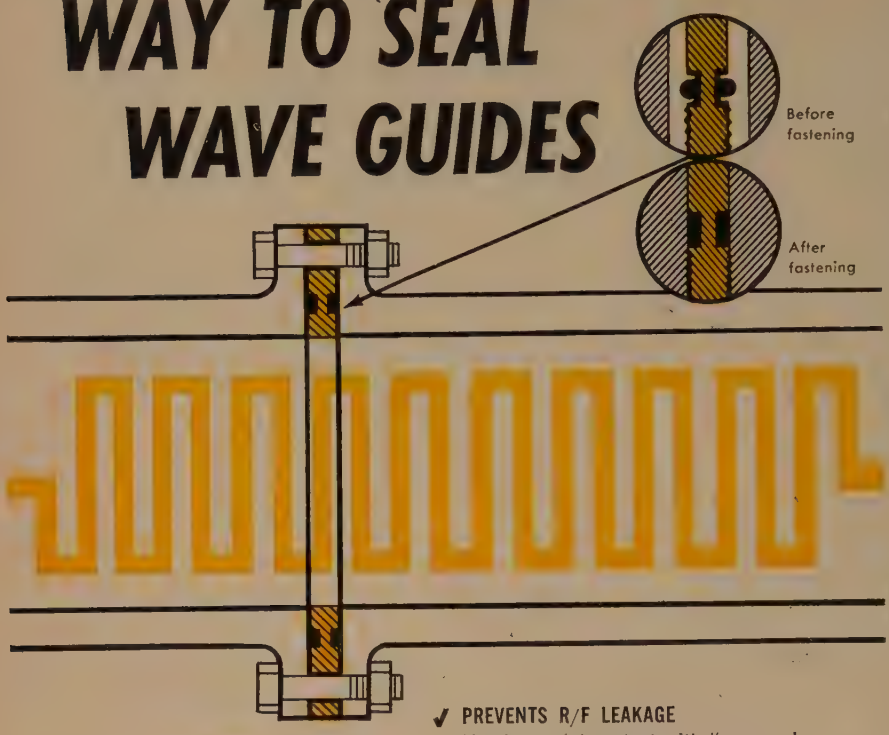
mediately Available
om Your Philco Industrial
emiconductor Distributor

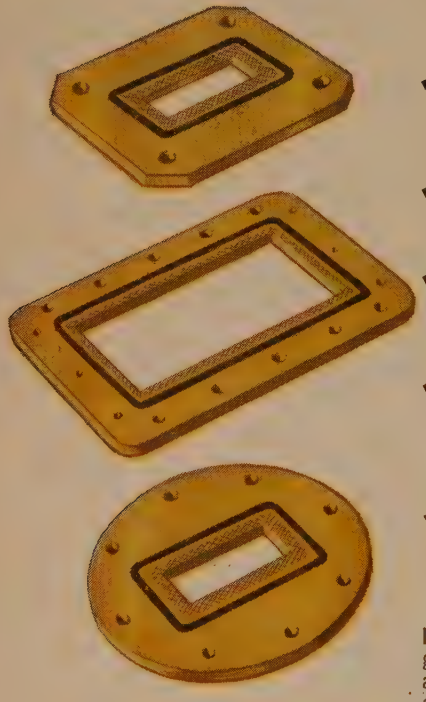
PHILCO®

Famous for Quality the World Over

LANSDALE DIVISION • LANSDALE, PENNSYLVANIA

NOW THERE IS A BETTER WAY TO SEAL WAVE GUIDES





✓ **PREVENTS R/F LEAKAGE**
Metal-to-metal contact with "engraved fingers" on inside surfaces assures electrical continuity.

✓ **PROVIDES NO-LEAKAGE SEALING**
Controlled confinement of seal gland assures safe, sure, positive sealing — **exceeds** top hermetic specs!

✓ **ELMINATES ARCING AND/OR BURNING**
Designed to exacting requirements for proper mating of flanges as specified.

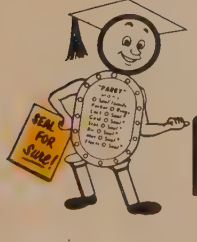
✓ **CAN BE RE-USED**
Seal is never "squeezed" beyond elastic limits, "memory" is constant, before, during and after fastening.

✓ **ECONOMICAL**
Eliminates cleaning or resurfacing flanges, no intricate machining required to accommodate the seal, and they're resuseable with just normal care.

✓ **STANDARDS FOR W/R SERIES**
Electr-O-Seals are available as standards to WR series Wave Guide flanges, assuring adequate supply and economy.

In addition to the standard WR series wave guide flange seals, Parker Seal Company also makes special seals to meet almost any specification or configuration. A nation wide group of field engineers are available to aid in expediting your requirements.

For more complete information send for catalog 5801.



Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio
A DIVISION OF PARKER-HANNIFIN CORPORATION

Circle Reader Service Card 12

Industry News

(*Continued from page 14*)

ARDWIN OPENS NEW DEPARTMENT

Ardwin Microlab Inc., Stoneham, Mass., announces the establishment of a new department for the design and production of electronic counting devices for laboratory and industrial use.

S. Stowe Sayward, vice president of Engineering for Ardwin, will manage the new department. Mr. Sayward was formerly chief engineer for the Electronic Control Division of Veeder-Root Inc. and manager of Equipment Development at Champion Lamp Works.

According to William P. Toorks, president of Ardwin, "The purpose of this department will be to provide dependable, transistorized counting devices for packaging machinery, laboratory use or industrial controls. Standard units will be available, but we plan to emphasize special equipment designed for particular applications."

Ardwin Microlab Inc. currently designs and fabricates components for the microwave industry. The company feels that the electronic controls department will also enable them to undertake development of electronic microwave systems.

—*mwj*—

PERSONNEL CHANGES AT D. S. KENNEDY

William Moran, formerly vice president of Master Fabricators, Inc., Birmingham, Alabama, has been named general manager of the Anniston, Ala., plant of D. S. Kennedy & Co.

Clyde F. Mooney, Kennedy president, said Moran replaces John Cunniff, acting general manager since late last year. Cunniff returns to the Cohasset, Mass., plant of the firm as plant superintendent, where he replaces Phillip E. Young who has become chief tooling engineer.

D & S Kennedy designs and manufactures antennas for radio telescopes, satellite trackers, communications, and radars; and, utility transmission towers and switchyard equipment. It has plants in Anniston, Cohasset, Hurst, Texas, Ft. Madison, Iowa, and a research and development facility at Monterey, Cal.

—*mwj*—

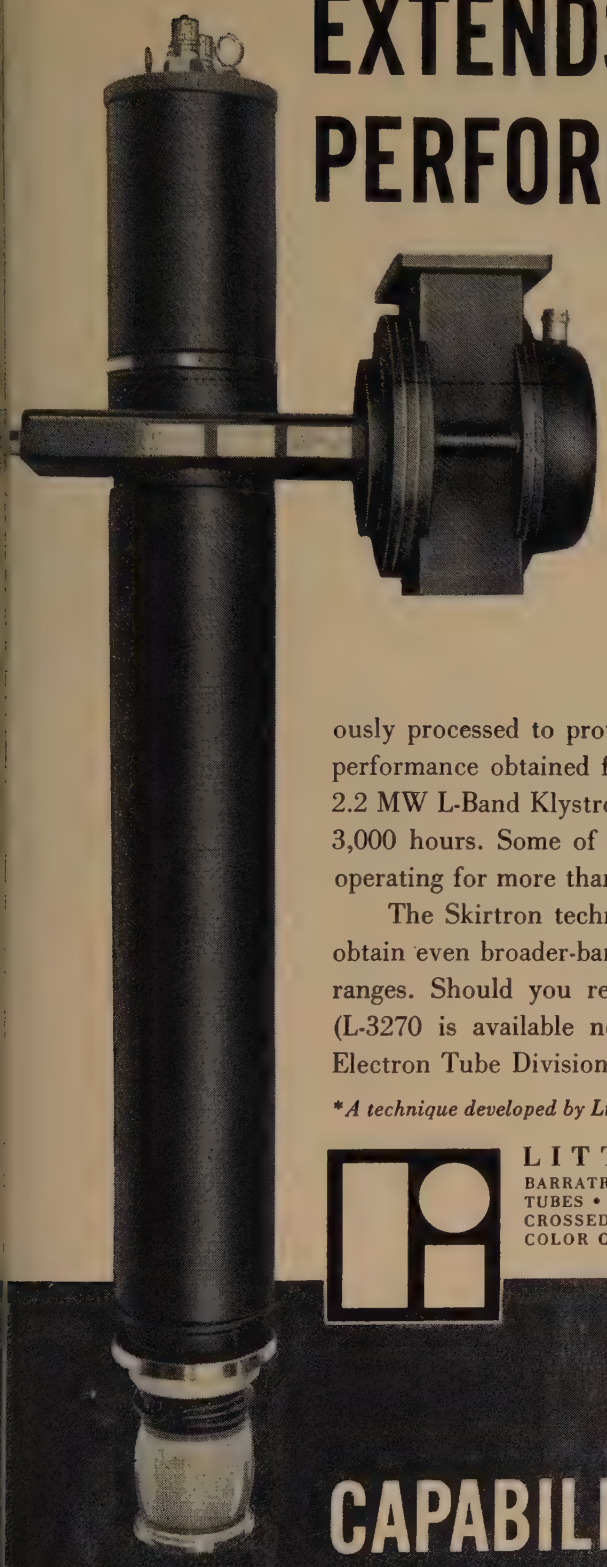
DAVIES-SHEA FOUND NEW FIRM

Eugene B. Shea, formerly executive vice president, and Charles A. Davies, vice president in charge of the Electronics Division, of Cadillac Associates, have announced their resignation from that firm in order to start their own organization devoted exclusively to professiona

(*Continued on page 18*)

Circle Reader Service Card 13

L-BAND KLYSTRON EXTENDS BROADBAND PERFORMANCE



This addition to Litton Industries' Klystron family not only extends the bandwidth of our broadband L-band amplifier tubes, but does so in a reduced package size. Through improvements of the recently developed Skirtron* bunching technique, the L-3270 achieves gain and power output characteristics, which are essentially flat over the minimum bandwidth of 100 Mc. Its minimum peak power output at the band edges is 2 MW. A linear phase shift versus frequency characteristic makes it ideally suited for application in sophisticated radar systems, where electronic tuning and pulse shaping are required.

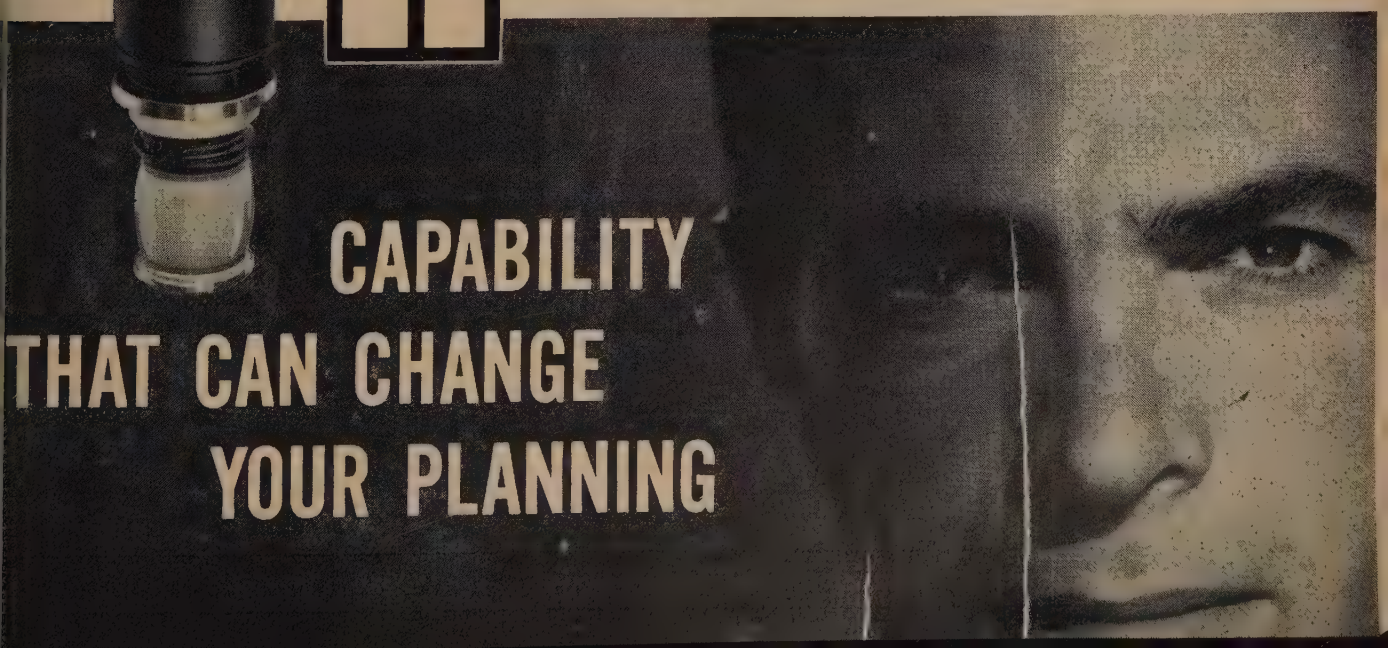
This tube, like all other tubes produced by Litton Industries, is conservatively designed and rated; and rigorously processed to provide thousands of hours of reliable operation. Typical of the performance obtained from applying this design philosophy is that of the L-3035, a 2.2 MW L-Band Klystron, whose *average* operating life in field service is approaching 3,000 hours. Some of these tubes are continuing to provide top performance after operating for more than 10,000 hours.

The Skirtron technique is being applied to other tubes now being developed to obtain even broader-band performance at higher power levels and in other frequency ranges. Should you require high power broadband performance for your current (L-3270 is available now) or future system planning, write to Litton Industries, Electron Tube Division, Office M12, 960 Industrial Road, San Carlos, California.

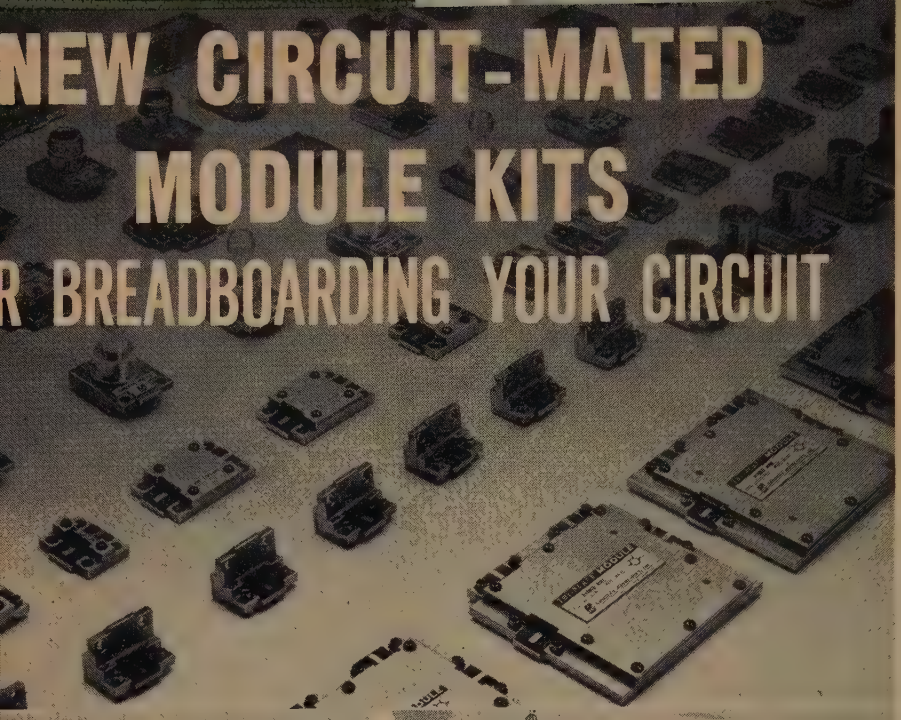
**A technique developed by Litton Industries which provides improved broadband performance.*

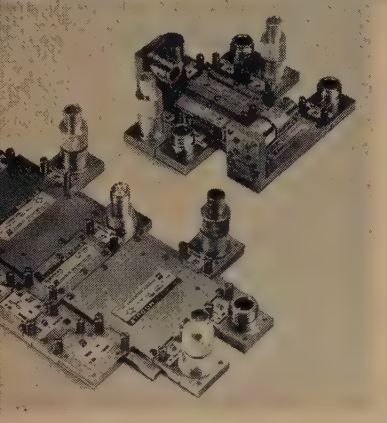
LITTON INDUSTRIES Electron Tube Division

BARRATRON® TRANSMITTING TUBES • MAGNETRONS • KLYSTRONS • TRAVELING WAVE TUBES • BACKWARD WAVE OSCILLATORS • GAS DISCHARGE TUBES • NOISE SOURCES CROSSED-FIELD AMPLIFIERS • HIGH DEFINITION CRT • DIRECT-WRITING CRT COLOR CRT • STORAGE TUBES • MICROWAVE FILTERS • DUPLEXERS • TR TUBES

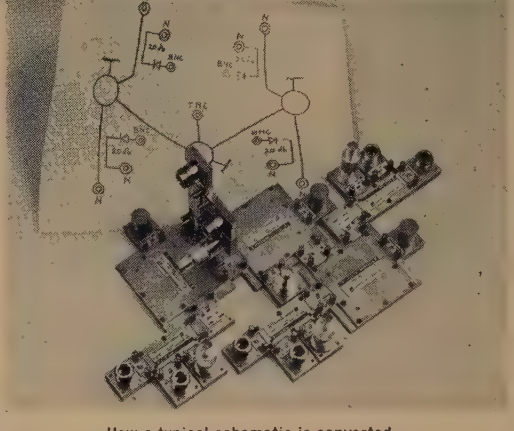


NEW CIRCUIT-MATED MODULE KITS
R BREADBOARDING YOUR CIRCUIT





2 examples of breadboard circuits
e from Standard Tri-Plate Module Kits.



How a typical schematic is converted
to a breadboard using a Circuit-Mated Kit.

SANDERS TRI-PLATE®
TRIP TRANSMISSION MODULES
ARE TESTED SHORT-CUTS TO
MICROWAVE PROGRESS!

Breadboarding Kit of these on-the-shelf modular components with tegral connectors can cut the time lag between your new design d a working circuit to a matter of minutes.

ailable in Standard Kits to meet most requirements or send us your rcuit diagram and get a quotation on a Sanders Circuit-Mated odule Kit.

ew Bulletin on Module Kits now available. Write for your copy.

® Sanders Associates, Inc.

SANDERS ASSOCIATES, INC.

roduct Manager, Microwave Products Dept., NASHUA, NEW HAMPSHIRE

Industry News

(*Continued from page 16*)

personnel placement and procurement in the electronics field.

The new firm, to be known as Davies & Shea, Inc., will be located in Chicago, Ill.

—*mwj*—

LANSDALE DIVISION OF PHILCO ANNOUNCES NEW APPOINTMENTS

Stephen L. Levy

William J. Peltz, vice president and general manager of the Lansdale Division of Philco Corporation, has announced new divisional staff and managerial appointments as part of the expansion planning of this Philco division.

Stephen L. Levy has been appointed assistant to the vice president and general manager of the division. Mr. Levy joined Philco in 1956 as manager of commercial engineering for the Lansdale Division, a position he held until his new appointment.

Announcement was made of the appointment of H. Kenneth Ishler as general manager of semiconductor operations. Mr. Ishler's functions will include overall responsibility for research, production, engineering and marketing of the division's semiconductor products.

Raymond M. Cotter has been appointed director of manufacturing for semiconductor operations, and George W. Pratt has been appointed director of engineering service.

—*mwj*—

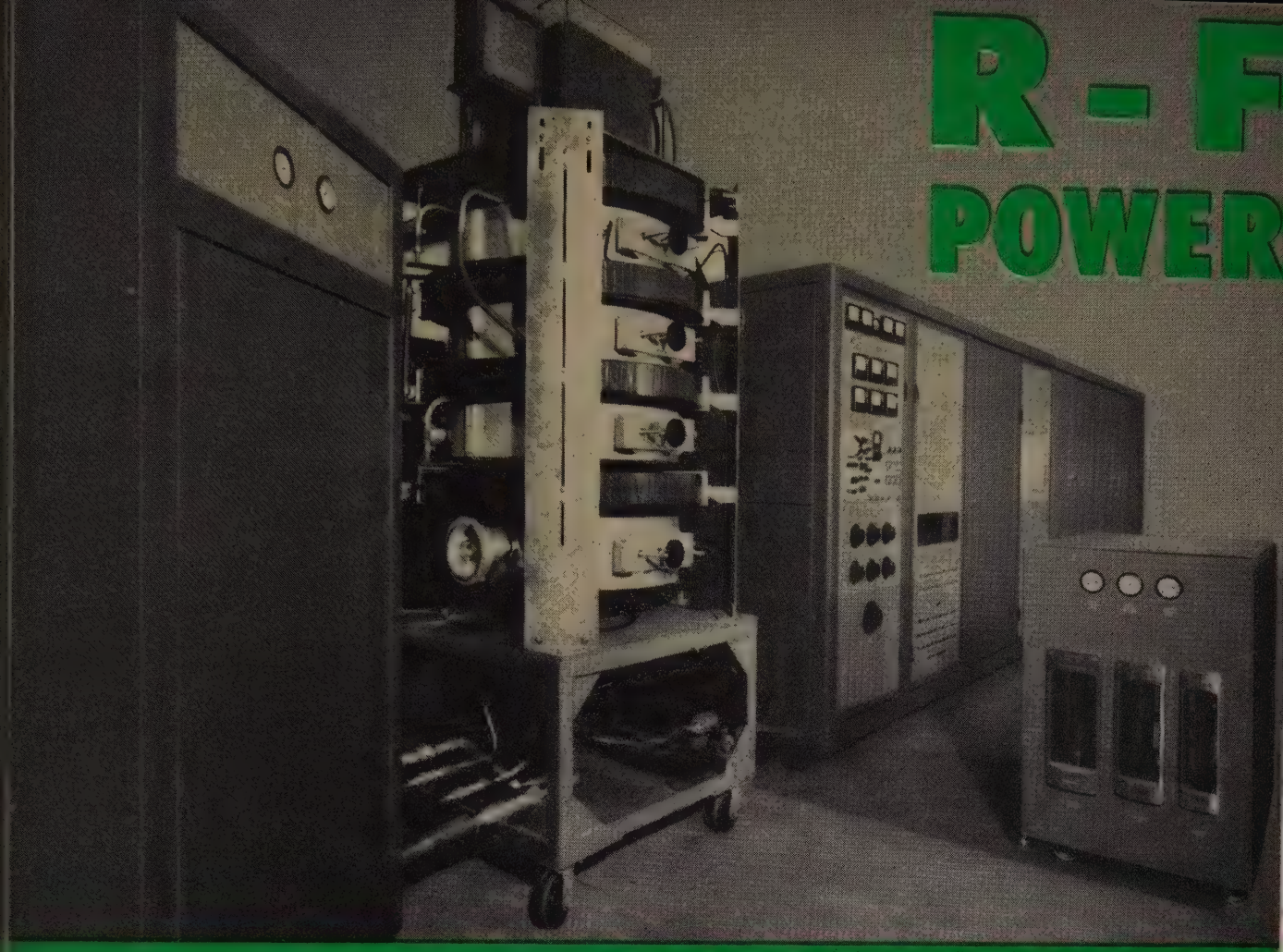
L. W. AURICK NAMED BY RCA

Appointment of Leland W. Aurick as manager, Advertising and Sales Promotion, Industrial Market, RCA Electron Tube Division, Harrison N.J., was announced by Harold S. Stamm, manager, Advertising and Sales Promotion.

In his new post, Mr. Aurick will be responsible for all phases of the advertising and sales promotion programs of the Division's products for the industrial market.

(*Continued on page 22*)

Circle Reader Service Card 70



R-F POWER

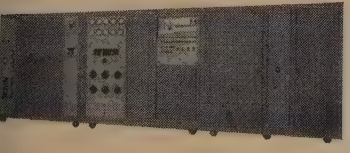
ackaged by LEVINTHAL

hese examples cover four ranges of Levinthal klystron ower amplifiers. All of them are of top commercial uality and all are suited to the requirements of power- ncrease problems in existing systems. They can be upplied for c-w or, with various types of modulators, or pulse operation. Further, any of them can be supplied with a signal-source driver to operate as a complete transmitter.

One of these may be the solution for one of your current problems. If not, tell us what your needs are and let us supply information on other examples of our equipment engineering.

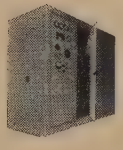
50 KW—MODEL 241T

his equipment, illustrated above, is typically capable of 50-kw c-w output ith 45-db gain in the 300 to 500-mc range, using an Eimac 4KM170,000LA lystron. Pulse capability up to 200 kw can be provided.



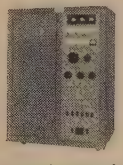
10 KW—MODEL 82T

Considering tubes readily available, this Levinthal transmitter can be supplied with typical gains ranging from 25 to 40 db in frequency bands ranging from 225 to 2400 mc.



2 KW—MODEL 208T

Here, a series of typical klystrons gives a selection of operations with gains from 30 to 50 db over frequency bands including extremes of 385 and 8500 mc.



1 KW—MODEL 74T

A variety of klystrons is available to provide the Model 74T with typical gains from 25 to 60 db and frequency bands ranging from 385 mc to 10.8 kmc.

Levinthal specializes in the production of high-power r-f transmitters and modulators for c-w or pulsed application. There are presently numerous attractive openings in the expanding engineering force at Palo Alto. If you are thinking about a new direction in your career, send us your resume and let us tell you something about the general advantages of working on the San Francisco Peninsula and those applying to Levinthal in particular.

LEVINTHAL ELECTRONIC PRODUCTS

STANFORD INDUSTRIAL PARK PALO ALTO, 7, CALIFORNIA

SUBSIDIARY OF RADIATION INCORPORATED

Circle Reader Service Card 15

NEW FROM NARDA

MICROWAVE MODULATOR

accepts over 40 magnetrons!

Here's the first of a series of new products from Narda's recently-established High Power Electronics Division! A high power Microwave Modulator that permits installation **inside the unit** of any of more than 40 magnetrons! Complete, compact and self-contained, it accepts magnetrons covering 3,200 mc to 35,000 mc, with peak outputs from 6 KW to 120 KW. Model 10001 features a completely interlocked circuit, with all high voltage leads and connections **internal,** for maximum safety; solid state high voltage bridge rectifiers for longer life and reduced heat output (prolonging life of other components, too); and built-in meters and viewing connectors for all principal parameters.

Other features are shown below. For complete specs and a list of at least 40 magnetrons suitable for use with the 10001, write Narda's High Power Electronics Division (HPED) at Dept. MJ-7.

SPECIFICATIONS

High voltage supply: Continuously variable from 0 to 4 KV at 100 ma; **Pulse power:** 18 KV at 20 amps max.; **Magnetron filament supply:** Cont. variable from 0 to 13 volts at 3 A; **Rep. rate generator range:** Cont. variable from 180 to 3000 pps; **Pulse width:** 1 microsecond at 70% points, rise time 0.15 microseconds, max. slope 5% (other pulse widths available); **Size:** 38" h, 22" w, 18" d. **Weight:** 150 lbs.

Complete 1959 catalog available on request.

the narda microwave corporation

HIGH POWER ELECTRONICS DIVISION

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Books of Interest

"Materials and Techniques for Electron Tubes"
by Walter H. Kohl
Published 1960 by Reinhold Publishing Corporation, New York, New York for the General Telephone and Electronics Technical Series, 603 pages plus 14 pages Appendix plus 9 pages Author Index plus 11 pages Subject Index plus XViii pages — $16.50.

Reviewed By Marshall C. Pease
Associate Editor
the microwave journal

This is a much revised version of W. H. Kohl's earlier book on "Materials Technology for Electron Tubes," published in 1951. The author states that "it is intended as a source of information for the tube engineer, the experimenter in the laboratory, and the technician, all of whom need to know how the basic materials behave under given conditions, and what techniques are available for assembling these materials into useful structures."

That this book has tremendous potential value for anyone using the techniques of electron tube design is obvious. Such a person must use an extremely wide range of materials and techniques. His problems are highly critical and he must use the best techniques as well as the most suitable materials that he can lay his hands on. It is his job to integrate the various possible methods with the particular exigencies of his purpose to produce the best result possible at the present "state of the art." To have available a wide-range but yet detailed survey of this multiplicity of opportunity gives him at least a fighting chance.

The scope of this book may be seen by running down its index. It includes chapters on the available glasses, ceramics, natural and synthetic micas, and on carbon and graphite. There are chapters on ferrous alloys, copper and its alloys, nickel and nickel alloys, tungsten, molybdenum and tantalum and mobium. Techniques are covered in chapters on brazing, glass-to-metal seals, ceramic-to-metal seals, cathode materials, structures and processing, and getters.

The depth of the survey may be indicated by the fact that the number of references cited exceeds 1100.

Having said this, however, we must also say that the microwave tube field is different from, though a part of, the general tube field. It has its own needs and technologies, some of which are not given adequate coverage in the book. Clearly any survey must cut off somewhere, but one can wish that the author had gone just a little bit further.

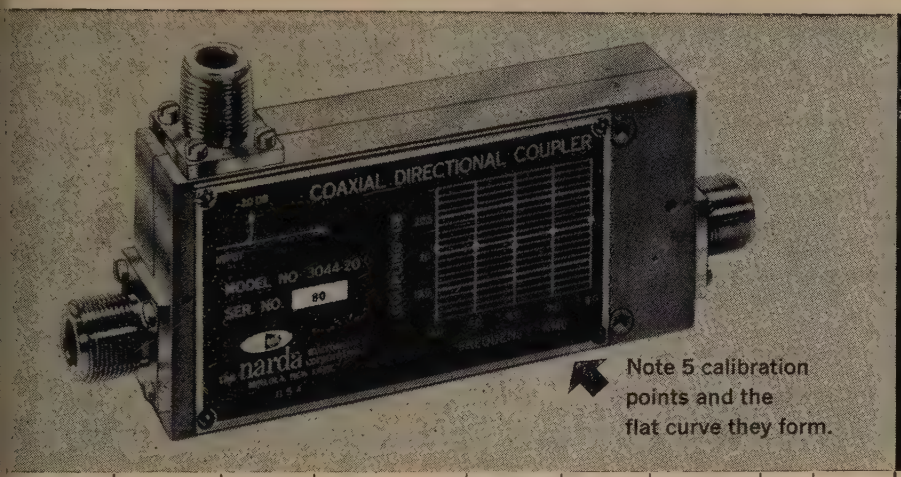
(*Continued on page 86*)

NEW FROM NARDA

THE INDUSTRY'S FLATTEST COAX COUPLER!

Only 0.2 db variation over full octave!

What more is there to say? The new series of Narda Coaxial Couplers is absolutely the flattest on the market; the specs are here; the prices are here. And you know Narda's reputation for quality! If you need a really flat coupler, contact your Narda representative, or write to us directly.



Note 5 calibration points and the flat curve they form.

Coupling Characteristics

Frequency Response	±0.2 db
Deviation of Mean Value from Nominal	±0.3 db
Calibration Accuracy	±0.1 db

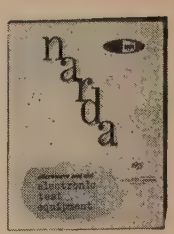
Calibration points at 5 frequencies

Connectors: Series N female; others on special order.

Frequency (mc)	Nominal Coupling	NARDA Model	VSWR Primary, VSWR Secondary	Minimum Directivity (db)	FORWARD (watts)	Power Rating REV. (watts)	PK. (kw)	Price
240-500	20	3040-20	1.1/1.2	20	1000	100	10	$200
500-1000	20	3041-20	1.1/1.2	20	1000	100	10	
950-2000	20	3042-20	1.1/1.2	20	1000	100	10	
000-4000	20	3042-20	1.15/1.2	20	1000	200	10	
000-8000	20	3044-20	1.2/1.25	17	1000	200	10	
000-11,000	20	3045-20	1.25/1.3	15	1000	200	10	

SEND FOR FREE 1959 CATALOG

Write for your free copy of Narda's new 1959 catalog. Address: Dept. MJ-14.



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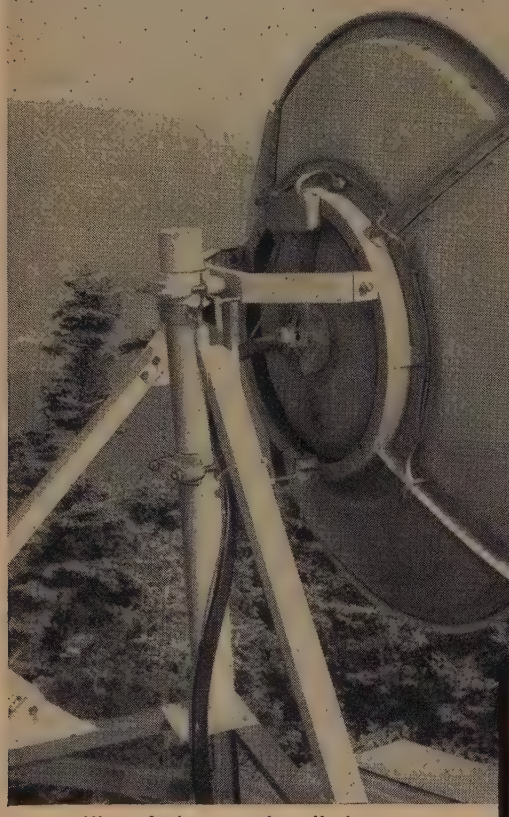
Proven Performance!



View of microwave installation atop Mount Pico, Vermont. Altitude 4,000 feet.

. . . proven performance, where rough conditions are normal all year. Here is a high mountain-top tower where ANDREW equipment was installed to perform, exposed to 100 mph winds, driving sleet, ice and snow.

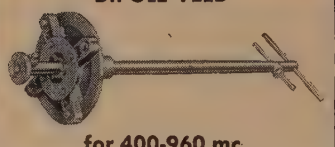
Selection of the best antenna systems for such problem installations is made easy through a choice of 30 ANDREW stock parabolic reflectors, which utilize the three standard microwave feeds. And tower work has been simplified too, with the new mount, which has separate elevation and azimuth adjustments for precise alignment.

All standard ANDREW antennas meet or surpass EIA recommendations and FCC specifications, governing radiation patterns and side lobes.

Uniform all weather performance is assured by the use of radomes and built in automatic de-icing equipment.

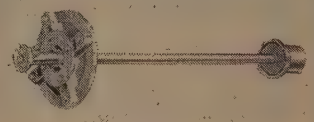
Why not check today on how you can get the maximum performance in your installation—just call the ANDREW Engineer in your area or write

DIPOLE FEED



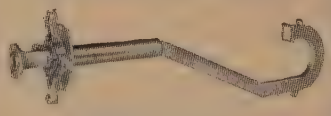
for 400-960 mc

COAXIAL HORN FEED



for 1700-2700 mc

WAVEGUIDE HORN FEED



for 3700-13,200 mc

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Displaying 6 kmc dual polarized antenna system and the new HUBLOC antennas.

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ANTENNAS, ANTENNA SYSTEMS, TRANSMISSION LINES

Industry News

(*Continued from page 18*)

Mr. Aurick joined RCA in 1957 as administrator, Industrial Advertising, and has been engaged in directing industrial advertising in both the renewal and original equipment markets.

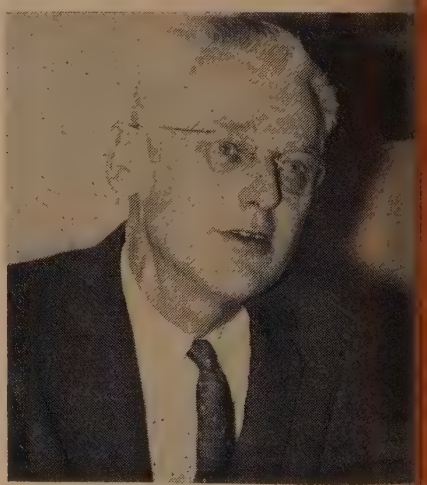
—mwj—

DR. SKIFTER RETURNS TO POSITION AS PRESIDENT OF AIRBORNE INSTRUMENTS LABORATORY

Dr. Herbert F. York, director of Defense Research and Engineering, has announced that Dr. Hector R. Skifter has resigned as assistant director of Defense Research and Engineering (Air Defense).

Dr. Skifter is resuming his duties as president of Airborne Instruments Laboratory, a division of Cutler-Hammer, Deer Park, N.Y., and vice president and member of the Board of Directors of Cutler-Hammer, Inc.

In 1957 Dr. Skifter served the Department of Defense as a part-time consultant. In February, 1959, he took a leave of absence from his position as president of Airborne Instruments Laboratory to accept the full-time position of assistant director of Defense Research and Engineering. During his period of office, Dr. Skifter was responsible for technical evaluation and integration of defense weapons systems, planning and supervising the development of new and improved systems and their control environment, including anti-aircraft and anti-missile missiles and interceptor aircraft.



As part of his duties Dr. Skifter served as chairman of the Ballistic Missile Defense Steering Group, spearheaded the installation of the BMEWS (Ballistic Missile Early Warning System) program and coordinated the planning for the development of the NIKE-ZEUS and the ARPA DEFENDER programs. He served as a member of the Department of Defense Panel for the evaluation program of the BOMARC Weapon System and was the chairman of the U. S. Delegation to the Tripartite Conference (United States, United Kingdom, and Canada) Technical Subgroup on Defense Against Ballistic Missiles.

(*Continued on page 34*)

new high-power harmonic ABSORPTION filter for SL band—1700 to 2400 mc

Harmful harmonic interference from high-power microwave equipment should be, **and can be,** eliminated at the source. These unwanted signals literally disappear when passed through Sierra's new Model 204A Waveguide Filter.

Representing a new approach to the elimination of harmonic interference, the Model 204A actually absorbs the unwanted energy with no appreciable attenuation of fundamental signals within the pass band. High order harmonic, as well as low order, are equally attenuated.

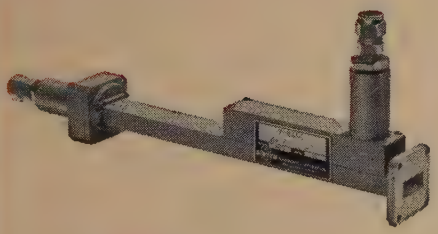
Currently available for SL band frequencies, Model 204 type filters can be supplied for other frequency ranges on special order. See your Sierra representative or write direct.

Sierra 204A SL Band Pass Filter

SPECIFICATIONS

Pass Band:	1700 to 2400 MC
Insertion Loss:	Less than 0.1 db in pass band
VSWR:	Less than 1.1 in pass band; less than 1.3 above pass band
Attenuation:	40 db minimum, 3400 MC to 11000 MC Same as RG-104/U below pass band
Maximum RF Power:	25 KW average, 1 megawatt peak
Size:	45" long, 12⅜" wide, 10⅜" high; weight 120 pounds.
Connections:	UG 435A/U Flange
Price:	Model 204A (SL Band) $2,195.00

Data subject to change without notice



WATER LOADS FOR POWER MEASUREMENT

New Sierra Water Loads permit convenient, accurate calorimetric wattage measurements; also serve as dummy loads and terminations.

For average powers up to 100 to 2000 watts, dc to 4 KMC, Sierra offers Model 186A Coaxial Liquid Cooled Load. For waveguide measurements Sierra offers 187 Series Water Loads covering the X, XB, C, S, and SL bands with average power limits of 2, 3, 5, 10 and 20 KW respectively. Also available: Sierra 287 series Dual Water Loads for balanced measurements in X, XB, and C bands. Sierra 287A Loads include thermopile.
To dependably measure power dissipated in other loads, Sierra Model 189A Differential Thermopile is recommended.

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A Division of Philco Corporation

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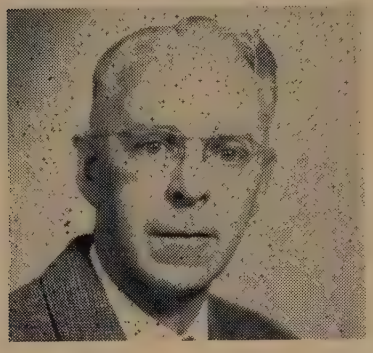
HAROLD S. BLACK, LAMME MEDALIST



A MAN WINS A MEDAL . . . AND STRENGTHENS A PHILOSOPHY

The search for the "hitherto unattainable" sometimes ends in strange places.

For years Bell Laboratories engineer Harold S. Black pondered a problem: how to rid amplifiers of the distortion which unhappily accumulated as signal-transmission paths were made longer and amplifiers were added. There had been many approaches but all had failed to provide a practical answer.

Then one day in 1927 the answer came —not in a research laboratory, but as he traveled to work on the Lackawanna Ferry. On a newspaper, Mr. Black jotted down those first exciting calculations.

Years later, his *negative feedback principle* had revolutionized the art of signal amplification. It is a principal reason why telephone and TV networks can now blanket the country, the transoceanic cable is a reality, and military radar and missile-control systems are models of precision.

For this pioneer achievement, and for numerous other contributions to communications since then (some 60 U. S. patents are already credited to him), Mr. Black received the 1957 Lamme Medal from the American Institute of Electrical Engineers. He proved that the seemingly "unattainable" often *can* be achieved, and thus strengthened a philosophy that is shared by all true researchers.

He is one of many Bell Telephone Laboratories scientists and engineers who have felt the challenge of telephony and have risen to it, ranging deeply into science and technology. Numerous medals and awards have thus been won. Two have been Nobel Prizes, a distinction without equal in any other industrial concern.

Much remains to be done. To create the communication systems of the future, we must probe deeper still for new knowledge of Nature's laws. We must continue to develop new techniques in switching, transmission and instrumentation for every kind of information-bearing signal. As never before, communications offer an inspiring challenge to creative men.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

ENGINEERING FOR SPACE

M. C. PEASE
Associate Editor
the microwave journal

We have recently read a new book on "Advances in pace Science, Vol. 1."[1] It is a volume that includes ort monographs, or long papers, on various aspects the problem of space exploration. The microwave rt of it occurs in a section on "Interplanetary Comunications" by J. R. Pierce and C. C. Cutler. But this only one part of the book. It also includes sections trajectories, power supplies, cabin systems, radiation fects, nutrition, and a decimal system for the cataguing of astronautic libraries. And these, of course, e only a few of the problems involved in the explorabn of space in general. None of these studies have any levance at all without the prime postulate that space to be explored.

The list of subject titles illustrates a situation that is ry interesting. Rarely, if ever, in the history of engining has it been necessary to solve such a diverse comex of problems before even beginning to make use of e answers. There are, to be sure, intermediate steps the program that do require less than final solutions all of the problems. Orbital satellites of various pes and functions, first unmanned and then manned, nar probes, lunar expeditions, planetary probes, and ally planetary expeditions. Not all of the problems ed to be solved for each of the steps. Not all of the eps even involve all of the separate problems. And r each step, the preceding ones will provide a prov- g ground and experimental and developmental labora- ry. The problem can and will be tackled in a stepwise anner.

The uniqueness of the problem arises from the facts, stly that there is such a diversity of problems, most which are relatively unique to this particular effort, d secondly that, for each step, the pertinent problems ust be solved to a high degree of competance before e step can be taken. The problem is stepwise, not ntinuous.

It will do no good at all to have a communication stem that can handle voice between Earth and Mars, we cannot feed an astronaut along the way.

And it will equally be useless for the expeditionary steps to have a nutritional system that is almost good enough — but not quite.

This is true across the board, including all the pertinent subproblems. And the range of these subproblems is fantastic. Alongside the communications problem is that of nutrition and the regeneration of the atmosphere. One approach to the latter involves the use of algae, thus involving a specialized branch of natural

history with strong overtones of biochemistry. In fact, it is basically a problem of ecology, the study of the interaction between an organism and its total environment. Here the problem is to set up a system which will include at least one man, and which will be ecologically stable over a sufficient period of time. This to be done under the constraint of minimum weight and maximum reliability. It is a strange problem to find as a bedfellow with one in microwave electronics.

(*Continued on page 27*)

Gabriel pioneers new ideas in antenna feeds and horns

Since the days when "Radar" was classified to present ultra-long-range space probings . . . Gabriel precision designed feeds and horns have been specified whenever tolerances and specifications were tight. In one of the first independent antenna research laboratories in the country, Gabriel pioneered in the development of sophisticated antenna feeds and horns.

Notable Gabriel contributions to advancement in the state-of-the-art include the use of high power, dual frequency and dual polarized feeds for radio astronomy and scatter communications . . . slotted feed systems up to six feet at Ka band . . . development of the first Infrared Deicer for large horn feed radomes used in the Dew, Pine Tree, and Aleutian Lines . . . study of Cassegrainian feeds for scatter and monopulse systems . . . and study of new feeds for systems using parametric amplifiers and masers. Write for specifications on the complete line of Gabriel horns and feeds.

New, circularly-linearly polarized, remote controlled feed horn for ASR-4 Airport Surveillance Radar Antenna provides excellent ICR to reduce out-of-phase signals from precipitation, dust and sea return.

PIONEERS IN ANTRONICS

Gabriel electronics DIVISION OF THE GABRIEL CO., MILLIS, MASS.

AIRPORT SURVEILLANCE RADAR ANTENNAS

ROTARY JOINTS

POINT TO POINT COMMUNICATION ANTENNAS

FEEDS AND HORNS

DRONE & DRONE CONTROL ANTENNAS

RESEARCH & DEVELOPMENT

C. Pease

(*Continued from page 25*)

It is true that neither of these problems are entirely ique to this application. Sensitive long range com- nication is a problem on Earth. And the ecologic oblem exists to some extent inside a submarine — re so on the newer nuclear subs that are capable of ying submerged indefinitely. The human organisms ide it are completely isolated from their normal en- onment. The ecologic cell that is its crew need not wholly self-sufficient, but it must be nearly so. This oblem, as well as that of maintaining the crew of a h altitude long-range bomber, is certainly related to t of engineering the internal environment of a space icle to make it life supporting.

The similarity is there, but it is weak. It is a qualita- e relation, with very little quantitative connection. e Navy, after all, even though it does seek to limit e to a reasonable degree, hardly pays any price at for excess weight.

There are, furthermore, differences of kind as well. e submarine, for example, has an unlimited supply water. If the price is right, it can generate its oxygen it goes. Presumably, it might even drag a net behind d gather all or part of its food. That it does not is a tter of economics, not of an essential boundary con- ion to the problem.

Or, in the communication problem, the principle uble on Earth is the fact that the Earth is round. ere is no line-of-sight path between the U.S. and rope. This, at least, is one problem that is missing in ace.

Another problem of earthside communications is the stence of scintillation (in its broadest sense) in the wer and upper atmosphere. This causes fading and uires excess capacity for reliability. It also, of course, ovides the means for one type of solution to the oblem of the Earth's roundness — i.e. scatter propa- ion.

In space we are dealing wholly with straight line ths without significant scintillation. (This is true n Earth-to-space, since the angle with the horizon ll normally be so large as to make scintillation effects mpletely negligible.) So that aspect of the problem missing. The problem, instead, is one of the enormous tances involved, and of the enormous cost of high wer in the middle of space.

There are, on the other hand, possibilities in space t are not practical on Earth. On earthside, we are ited in the size we can make our steerable antennas imarily by the problem of holding tolerance as its ect to gravity changes and under a fluctuating wind. viously, no such limits exist in space — at least until ngs get big enough, and fragile enough, to be sensi- e to light pressure! At least for permanent satellite tions, one can conceive of enormous antennas, several ders of magnitude bigger than anything now pro- ted for Earth. Whether this will be done or not, we nnot say. It will depend on economic factors. But it certainly a possibility that will have to be considered.

(*Continued on page 28*)

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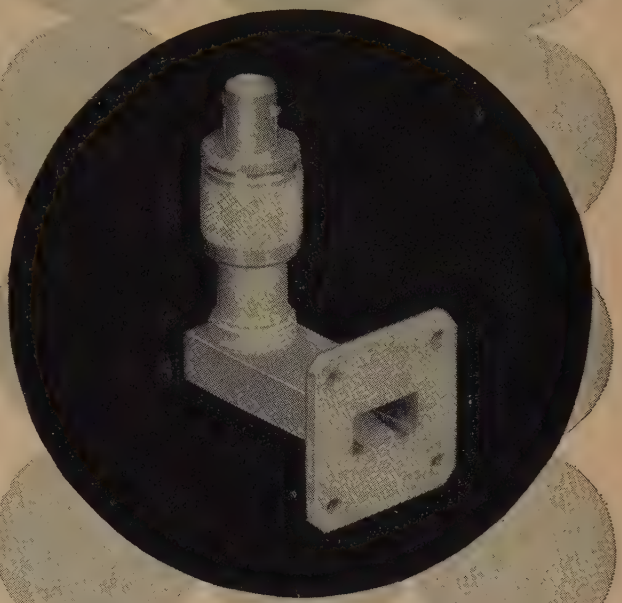
A NEW LINE OF

AEL

MICROWAVE COMPONENTS

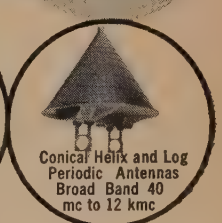


WAVEGUIDE CRYSTAL DETECTOR MOUNTS

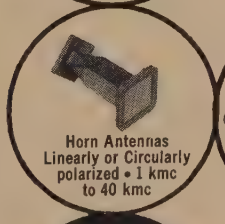
AEL proudly offers a new line of microwave WAVEGUIDE CRYSTAL VIDEO DETECTOR MOUNTS specifically designed for the High Tangential Sensitivity that has become the hallmark of *AEL's* detector mount program. Available for X, Ku, K and Ka bands.

Coaxial crystal detector mounts • 50 mc to 12 kmc

Waveguide Filters Band Pass and High Pass • 8.2 kmc to 40 kmc



Conical Helix and Log Periodic Antennas Broad Band 40 mc to 12 kmc



Horn Antennas Linearly or Circularly polarized • 1 kmc to 40 kmc

Coaxial Microwave Crystal Switches • 30 mc to 12 kmc

Waveguide Dummy Loads • Low VSWR Lightweight—High Power—High Efficiency

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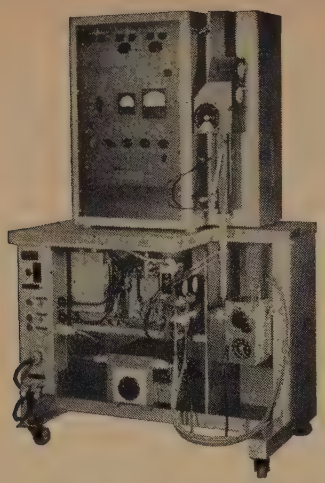


UNIQUE VERSATILE COMPLETE microwave dielectrometer

Measures dielectric constant and loss over a wide temperature range at 1, 3, and 8.5 kmc.

With a complete line of accessories the Central Research Laboratories Dielectrometer gives high accuracy and unequalled versatility.

Accessories now available: *Temperature Control Unit.* Enables dielectric properties of solids to be measured at any temperature between −30°C and +500°C; liquid samples to +150°C. Includes waveguide extension and sample holders for solids and liquids.

Room-Temperature Extension Sample-Holder. For measuring liquids or semi-solids at room temperature only.

Quarter-Wave Spacers. Accurately-cut, low-loss quarter wave spacers to make open-circuited measurements or gain greater sensitivity with thin samples.

For brochure giving details and specifications, write:

Central Research
laboratories, inc.

Circle Reader Service Card 22

M. C. Pease

(*Continued from page 27*)

There is, then, the need for completely rethinking the problem in a way to make sure that we are not being improperly influenced by the solutions that have proved useful on Earth. Indeed, our experience with related earthside problems may actually be a handicap leading us to place improper emphasis on certain approaches. Is proper attention being given, for example to the possibility of using incoherent energy in space-to-space links? Possibly such communication should be in the light part of the spectrum, rather than the electronic. We do not know. Perhaps it has been considered and properly rejected. Perhaps it still is being actively considered. We have not heard of such a study but this proves nothing. But one may wonder if the impracticability of such a means for a long range communication on earth may not lead to its being overlooked in space where conditions are so very different.

The history of earth-bound engineering on somewhat related problems is, therefore, completely inadequate and may be misleading. While existing technologies must provide the basis for the solutions of these problems, they do not, and can not, provide the solutions themselves. They do not even provide first approximations to the needed solutions.

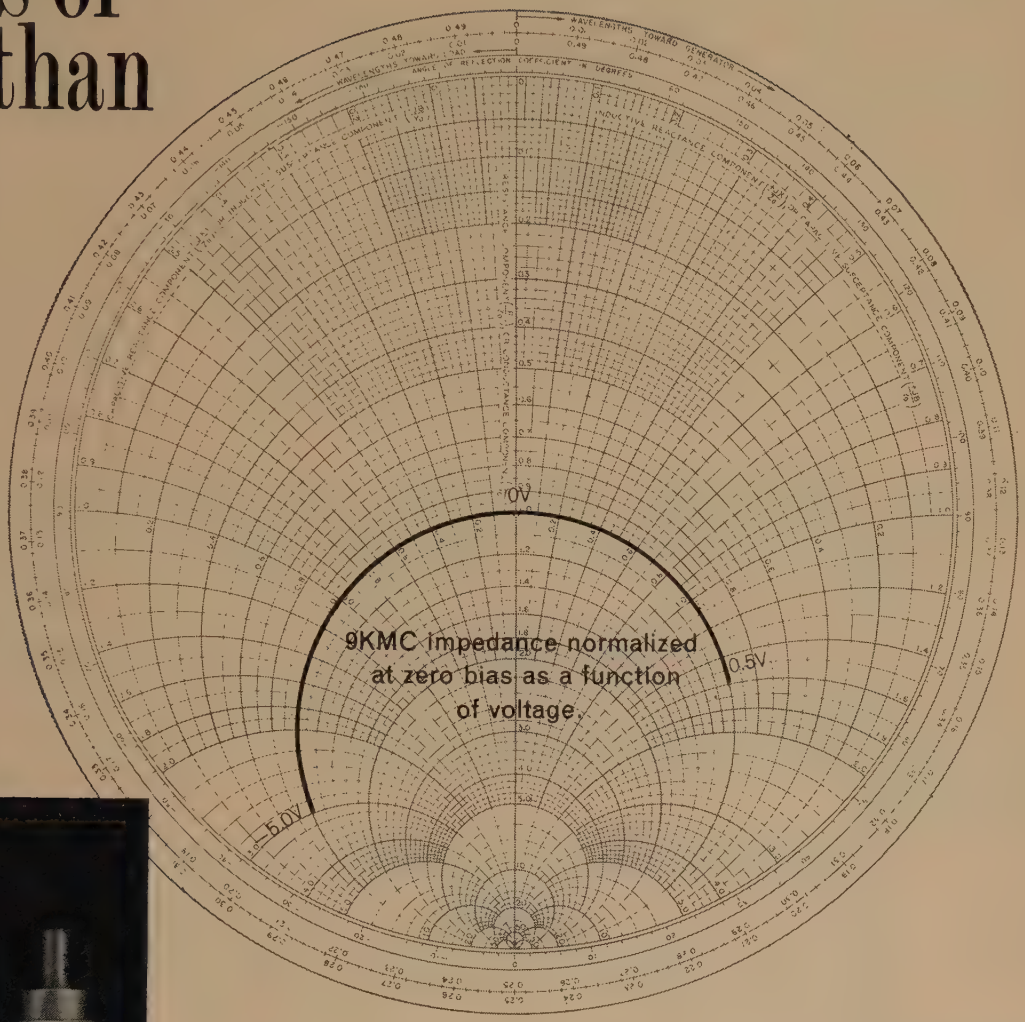
This is a situation that is relatively unique in the history of engineering. The first automobiles were literally horseless carriages on which a motor was placed. The result, by modern standards, was rather horrible. But it was able to be of use. Out of the experience of that usage, there was obtained knowledge of the problem, by which improvement could be projected. Since then, there has been a continuous history of development based on continuing experience. The line of evolution has been smooth. (We dodge the question of whether it has always been forward! We also, with malice, ignore the repeated claims of advertising concerning break-throughs and revolutions of design!) Nowhere has there been need for especially subtle engineering in the complete absence of practical experience.

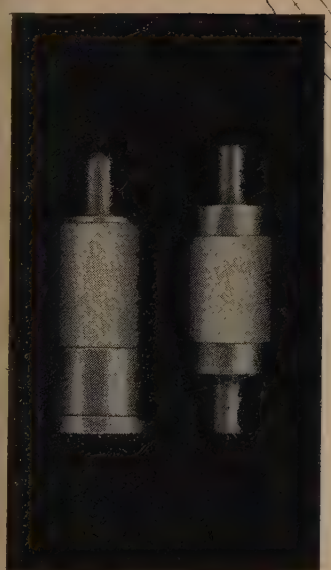
In the airplane, there was to some slight degree, an exception to this situation. To make the first airplane fly, there had to be a solution, however poor, to the aerodynamic problem coupled with solutions to new problems in structural and mechanical design. The first airplane did not look or function like any gadget then existing. Nor was it simply a combination of such gadgets, like the first automobile. It needed the solution to problems that did not occur in comparable form in any other device. Until this complex of problems had been given at least slightly satisfactory answers, there was no airplane.

The airplane, however, had this problem to only a slight degree. The wings of the Wright brothers' plane were, we imagine, appalling by modern standards. So, too, was everything else about it. The solutions to the subsidiary problems that did let that first plane fly were so far from being good that there is hardly any similarity between it and modern design. The complex of problems had to be solved, but the first step could be taken with exceedingly poor solutions.

(*Continued on page 31*)

for noise levels of less than 2 db





Hughes S and X Band Parametric Amplifier Diodes

Hughes has designed parametric amplifier diodes that can give you noise levels of less than 2 db at X band using double sideband operation. In addition to low noise, these HUGHES® diodes also offer a number of other advantages. First, their high cutoff frequency means that you can obtain higher amplification and higher harmonic generation. Their ceramic package reduces stray capacitance and makes for more dependable performance levels.

With these characteristics, Hughes S and X Band Parametric Amplifier Diodes are ideally suited to the following applications: radar preamplifiers, frequency converters, phase shifters and harmonic and subharmonic generators.

For additional information, please write: Hughes, Semiconductor Division, Marketing Dept., Newport Beach, California. *For export write: Hughes International, Culver City 5, California.*

Characteristics:

Cut-off Frequency @9KMC at zero bias..	30-70KMC
Capacity at zero bias.....	0.8 to 1.5μμf
Working Voltage @ 10μA.....	3.5 to 5.5
Lead Inductance @2KMC.....	3.5mμh

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HUGHES AIRCRAFT COMPANY
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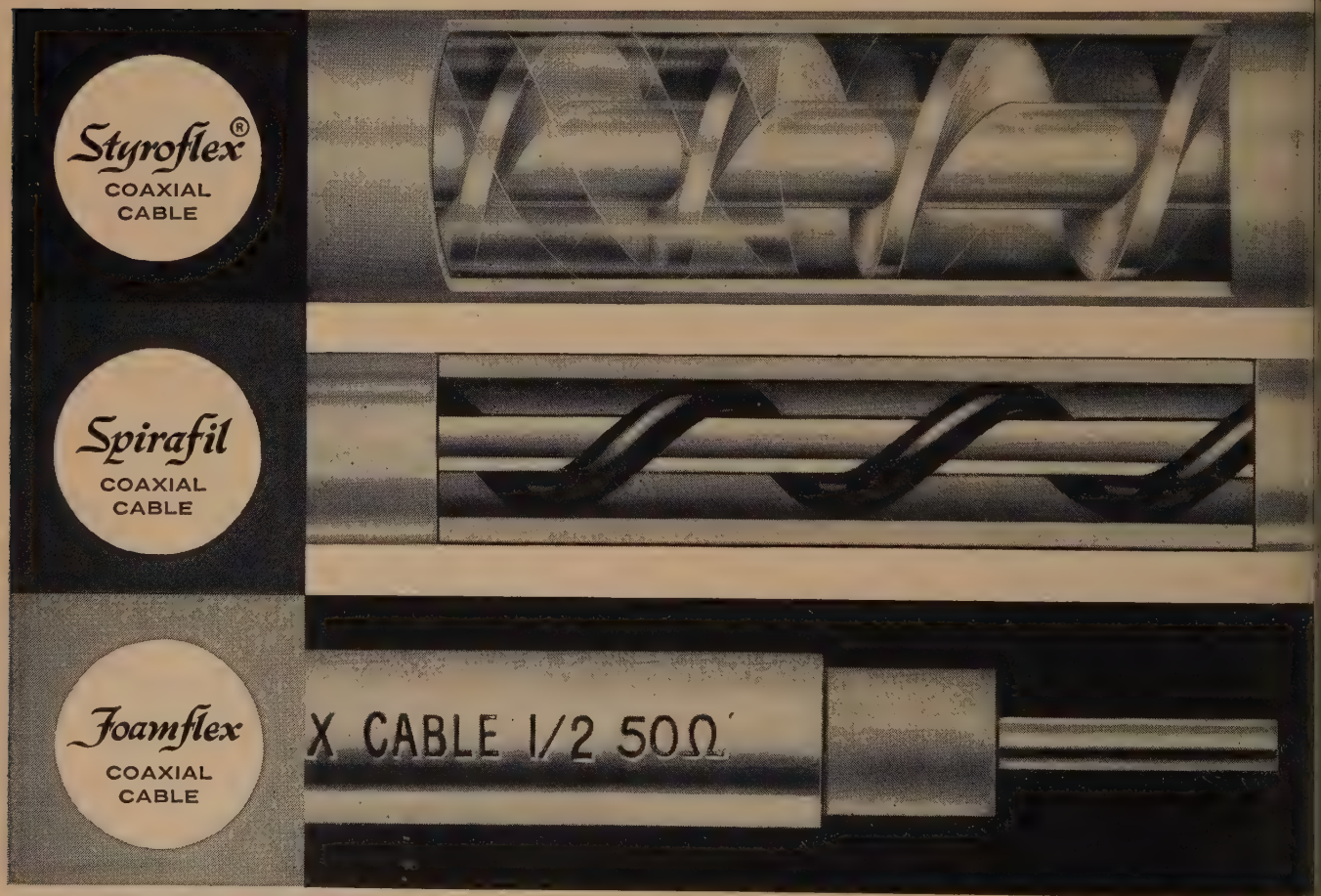
Finest line of High Frequency Cables in the communications field!

- No radiation
- Low attenuation
- Excellent frequency response
- Uniform electrical properties over wide temperature variations
- Unlimited operating life
- Continuous 1000′ lengths

Matching fittings for all cables are available from Phelps Dodge.



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M. C. Pease

(*Continued from page 28*)

This is not true in space flight. No doubt, when we are able to look back on the first manned space flight with the wisdom of fifty years of experience, its techniques will look to have been crude and fumbling. But they cannot be too crude. For crudeness means a penalty in size and weight, if not in reliability. The price that one pays in astronautics for even a slight unnecessary weight is itself astronomical. It is a project that will not tolerate anything but the highest degree of sophistication of which we are currently capable.

The term "sophistication" in this context does not necessarily mean complication or even, perhaps, subtlety of design. It means the use of all the resources of modern engineering and scientific knowledge in obtaining the best solution to the total problem. It means that an element must be designed, not in accordance with accepted design criteria, but to meet the problem that will actually exist in space.

As an example, a manned interplanetary probe or expedition will probably need microwave transmitter tubes. Solid state devices may be adequate for the low power requirements of satellites. Over the greater distances of interplanetary travel, higher powers than such devices can supply will probably be needed. Quite possibly what will be needed is the greatest power of which the technology is capable. With this, of course, will go the need for maximum reliability, together with the necessity for minimizing weight, and, to a lesser extent, size.

A great deal of work has been done in recent years towards the development of reliable power tubes. While we cannot deny that more needs to be done, nevertheless, progress has been very substantial.

In spite of this, it seems quite clear that, on a deep space vehicle, operating, say, from orbital station to station, reliability will be obtained by quite different techniques than those now being used. The reason is simple. Such a vehicle is always operating in an environment that is a better vacuum than anything we can obtain on earth. Since the maintenance of vacuum is one of the principal problems of reliability, the vacuum of space is a resource that can be profitably exploited. Furthermore, the vacuum envelope of a tube is a major contributor to its weight. There is considerable profit to be obtained in disposing entirely of the envelope, leaving only the inner parts of the tube, mounted quite simply on an optical bench, or perhaps clamped onto various parts of the vehicle as convenient. This would have the added convenience of allowing the direct replacement of component elements, thus reducing the maintenance problem further. It might even allow the mechanical shifting of parts to make the "tube" serve multiple functions, with further saving of total weight.

What remains does not look much like a tube. It ignores a major part of the tube technology that has been laboriously built up on earth, but it ignores it at a profit. It creates new problems. Some of these are the direct result of the environment. Do you need to protect the device against micrometeorites, or can you design it to accept the resultant erosion? Can you control heat dissipation? Can you control thermal expansion as its aspect to the sun changes? And so on.

Other problems arise by interaction with the human problem. How do you change the filament or gun of a tube, even if it is wide open, when you are encased in a space suit and under free fall conditions? How do you make the delicate adjustments that may be necessary? Can you make solder connections under these conditions? If not, what do you do? What, in other words, do you do to make it not only a good vacuum tube, but a practical one in the total situation including the conditions, physical and psychological, under which the maintenance operator must operate?

The problems must be thought through from fundamentals. And they must be thought through before we attempt to go into the situation that needs the solution. It is not needed in orbital vehicles. They do not need the power that will force the use of transmitting tubes. (Or will they, when we need more channel capacity than the initial probes have required?) It becomes necessary only when we start probing for the planets, and probably then only when we do it with manned vehicles. But at whatever step it becomes necessary to provide that kind of power, then we will be straining every technological muscle to make that step at all. It will be only just possible at our then existing state of knowledge. We will not be able to afford anything less than the best we can possibly do in any part of the vehicle, the term "best" being in reference to the total objective of the vehicle. We will not be able to afford using conventional tubes in that first effort. Later, perhaps we could. But not on the first such flight.

The problems of such a design concept will have to be tackled before the first such flight ever gets past the planning stage. They will have to be answered before there is any experience with which to guide the answer.

It is true in every engineering problem that it is the total problem, in its human and social aspects, that determines the solutions that apply. In most problems, however, there is enough experience so that proper boundary conditions can be specified for the separate pieces. Specifications can be written for the sub-systems and for the components. These can be written in engineering terms that submerge completely the ultimate human requirements. We tend to concentrate on these, forgetting that the total problem exists. We forget that the particular technology chosen is only the tool of that ultimate need, and not an end in itself.

One of the interesting aspects of the present challenge and struggle for space is that it cannot at this time, be handled in this manner. It is one area where the engineering, be it on the question of feeding the astronauts and rehabilitating their atmosphere, or on the design of deep space transmitting tubes, must be studied specifically in terms of the overall problem. It is a challenge that will use a whole complex of technologies in a highly interactive manner and under conditions for which we can gain no direct experience prior to their use.

It is a problem that is largely unparalleled in the history of engineering.

---

[1] Ed. by F. I. Ordway III, Published by Academie Press, Inc., New York 1959.

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CORPORATION

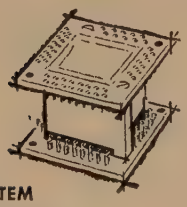
a new symbol of magnetic progress

Two established leaders — Indiana Steel Products and General Ceramics — Combine to Serve You Better

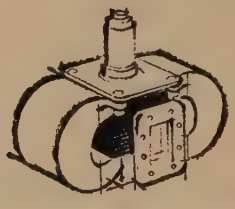
This trademark is the calling card of a new leader in science-age materials — Indiana General Corporation. It is born of a union between two established leaders — The Indiana Steel Products Company in permanent magnets . . . the General Ceramics Company in ferrites and memory systems. Together, as Indiana General Corporation, they serve you better by placing at your disposal the brains and resources of two scientifically oriented concerns. Research and development have been the backbone of both of the original companies; both have records of significant achievement in their particular fields.

Indiana General can help you "design-engineer" your products with the latest magnetic innovations. If you have a design problem, the Indiana General sales engineer in your area will be most happy to advise you. And, behind him, our experienced scientists and design engineers are available for consultations — at no cost or obligation. Write us outlining your problems.

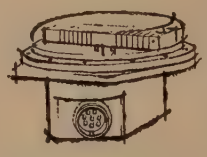
LOUD-SPEAKER
INDOX V ceramic permanent magnet provides high energy level . . . reduces speaker length and weight.



MEMORY SYSTEM
New microstack unit for coincident current memory systems saves 90% of space required by conventional stack, yet is more reliable.



MAGNETRON
Powerful Hyflux ALNICO V magnets improve performance in many types of microwave equipment.



AUTOMATIC DIRECTION FINDER
Ferramic "E" magnetic core material helped engineers create a new concept in aircraft antenna design.

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GENERAL CERAMICS DIVISION Keasbey, New Jersey • Ferrites, Memory Products, Technical Ceramics and Chemical Stoneware

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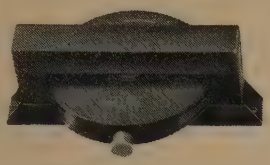
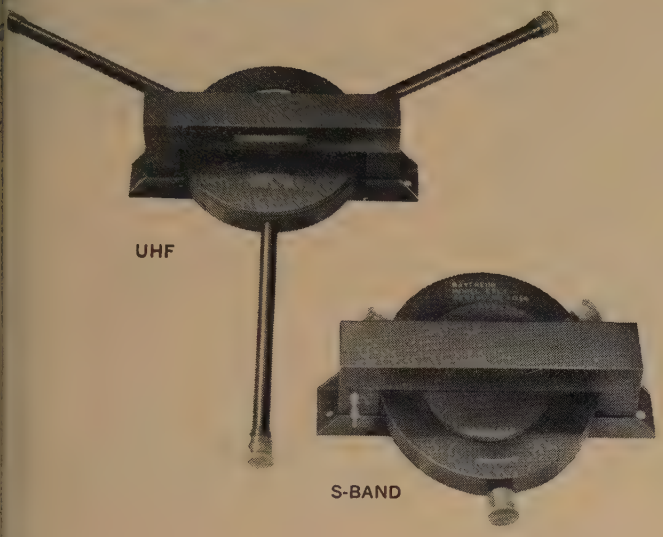
VALPARAISO, INDIANA

NEW 3-PORT CIRCULATORS FOR MASERS, PARAMETRIC AMPLIFIERS & RADIO ASTRONOMY



L-BAND



UHF

S-BAND

TWENTY EIGHT MODELS OF SMALL LOW-LOSS CIRCULATORS FOR L, S, AND UHF BANDS DOWN TO 350 MC

The unusually compact, low-loss, Raytheon circulator design first introduced for L-band applications last summer is now available in *28 standard models.*

The three-port circulators, designed for use with coaxial line, are supplied with fixed permanent magnets or with tunable electromagnets for operation over a broader band. Insertion loss is typically .4 db maximum.† Isolation on all units is 20 db minimum. VSWR is 1.25 maximum. See typical specifications at left.

To learn more about these significant developments or for information about other important Raytheon advances in microwave ferrite devices, please write, stating your particular area of interest, to the address below.

†L&S bands only. UHF insertion loss is typically .5 db.

TYPICAL SPECIFICATIONS

		L & S bands	
	UHF	Tunable units	Fixed units
Frequency range	any freq. from 350-800	any freq. from 800-3000	any freq. from 800-3000
Bandwidth	±5 mc	±50 mc above 1000 mc ±40 mc under 1000 mc	±25 mc above 1000 mc ±20 mc under 1000 mc
Isolation	20 db min. 25 db max.	20 db min. 30 db max.	20 db min. 30 db max.
Insertion loss	.4 db min. .6 db max.	.3 db min. .4 db max.	.3 db min. .4 db max.
VSWR	1.08 min. 1.25 max.	1.08 min. 1.25 max.	1.08 min. 1.25 max.
Power (av.)	5 watts	5 watts	5 watts
Power (peak)	5 kw*	5 kw*	5 kw*
Wt. (max.)	10.0 lbs.	10.0 lbs.	9.0 lbs.
Max. diam.	7½ in. excluding arms	7½ in.	7½ in.

ith type N connector. Powers as
gh as 90 kw are possible with type HN connector.

RAYTHEON COMPANY
SPECIAL MICROWAVE DEVICES OPERATIONS
WALTHAM 54, MASSACHUSETTS

RAYTHEON *Excellence in Electronics*

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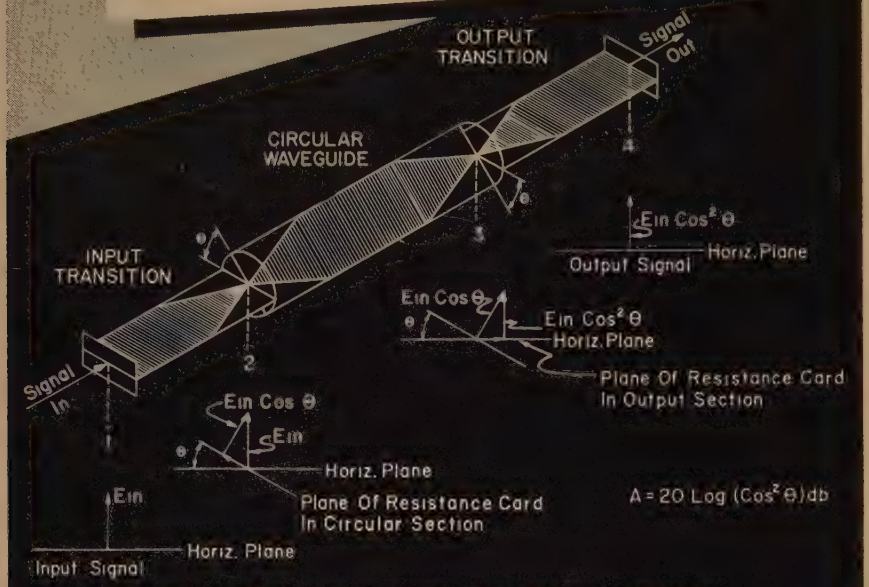
FUNDAMENTALLY SPEAKING!

SUBJECT:
MICROWAVE ATTENUATION



ROTARY VANE ATTENUATOR SCHEMATIC DIAGRAM

HOW IT WORKS

The attenuation of the rotary vane attenuator is a function only of the geometry rather than the resistive attenuation of the cards. Since geometry is not a function of frequency, the attention is not a function of frequency.

An understanding of the mechanism of attenuation will make this clear. The rotary vane attenuator is made up of three sections, two transitions from standard rectangular waveguide to circular waveguide on either side of a section of circular waveguide. Each section contains a thin vane of resistance card. A wave entering the attenuator at the input terminals has its electric vector perpendicular to the plane of the vane and will thus pass through the input transition unattenuated. The vane in the circular section can be rotated to any angle θ relative to the horizontal plane of the attenuator. Thus, the E field upon leaving the input transition finds itself at an angle $90°-\theta$ relative to the vane in the circular section. The component of the E field parallel to the resistive vane in the circular section will be completely dissipated by it, if the vane is long enough, while the component perpendicular to it will pass through the circular section unattenuated. The magnitude of the unattenuated component is Ein Cos θ. This component, Ein Cos θ, emerges from the circular section at an angle of $90°-\theta$ to the vane in the output transition. Thus, upon passing through the output transition, the wave again undergoes an attenuation of Cos θ. The magnitude of the wave emerging from the attenuator is, thus, Ein $\cos^2\theta$.

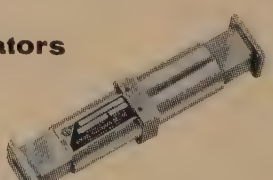
The attenuation of the attenuator in decibels is: $A = 20 \log \cos^2\theta$

It can be seen from a plot of attenuation as a function of the angle θ, that for attenuations up to about 25db, the attenuation is a very slowly varying function of θ. This characteristic allows the production of very precise wide band fixed attenuator pads.

Rotary Vane Fixed Attenuators

C.E.C. offers resistive attenuator pads that cover an entire waveguide band. These attenuators maintain a flat attenuation characteristic over their entire waveguide band.

ATTENUATION: 3db, 10db or 25db are offered as Standard. Other attenuation values can be preset to your specifications.



C.E.C. has for years been engaged in the design and production of quality components and systems for both military and industry. A member of our engineering group will be happy to meet with you on any microwave problems you now face.

CEC CONTROL ELECTRONICS CO., INC.

Industry News

(*Continued from page 18*)

SUOMALA TO GABRIEL ENGINEERING POST

The appointment of John B. Suomal as vice president of engineering of th Gabriel Electronics Division of Th Gabriel Company, has been announce by Stanton L. Yarbrough, president an general manager of Gabriel Electronic Mr. Suomala, formerly with the Instru mentation Laboratory at Massachusett Institute of Technology, has had over 1 years engineering and managerial exper ence in his field.

In this new position, he will be i charge of all matters in the engineerin department of this division, reporting di rectly to Mr. Yarbrough. He will direc projects now in progress leading to ac vanced product designs and will hav charge of all research and developmen engineering design testing and publica tion operations.

—*mwj*—

YOUNG NAMED HEAD OF MARKETING FOR PHILCO COMMUNICATIONS AND WEAPONS DIVISION

The appointment of Conrad Youn as marketing manager of Communication and Weapons Division for Philco Co poration's Government and Industria Group is announced by Joseph M. Herta berg, vice president-marketing for G & Mr. Young's appointment is effectiv immediately and his new duties are i addition to his present responsibilities a industrial products marketing manager fo the Philco Group. As marketing man ager for the Communications an Weapons Division, he will have ful responsibility for the direction of sale contracts and planning. Activities of thi division include Philco programs in com munications, radar, missile and missil fuzing fields.

Mr. Young joined Philco in 1952 an has held key positions in the Governme and Industrial Products Marketing Grou

—*mwj*—

(*Continued on page 36*)

LEADS THE INDUSTRY IN ULTRA-HIGH-POWER DUPLEXING

with both GAS DISCHARGE and FERRITE DUPLEXERS

Selecting a duplexer for high-power applications involves consideration of peak power, average power, transmit loss, receive loss, expected life, and versatility of operation.

All Microwave Associates high power gas duplexers utilize special window structures for optimum switching efficiency without sacrifice in low-level loss characteristics. These windows insure reliable, long-life performance. Both our gas and ferrite duplexers may be operated over very broad bandwidths at the common microwave frequencies.

Exceptionally complete ultra-high-power design and test equipment is utilized by our Research and Production Departments. Each duplexer is fully tested at maximum rated power before shipment.

We have extensive experience in designing and manufacturing high-power duplexer devices and are interested in working on newest ultra-high-power applications. We are now developing ultra-high-power duplexers for more efficient switching at UHF, L, C, and S bands.

Our Applications Engineers would like to discuss the future of high power duplexing with you.

Frequency Band	Duplexer Type	Peak Power	Average Power	Transmit Loss (max.)	*Receive Loss (max.)	Bandwidth
UHF	Gas	5 Mw	300 Kw	0.1 db	0.4 db	Tunable
	Gas	25 Mw	75 Kw	0.1 db	0.4 db	
L	Gas	25 Mw	50 Kw	0.1 db	0.5 db	
S	Gas	6 Mw	30 Kw	0.1 db	0.7 db	
	Ferrite	3 Mw	5 Kw	0.5 db	0.9 db	
C	Gas	5 Mw	5 Kw	0.1 db	0.7 db	
	Ferrite	5 Mw	7.5 Kw	0.3 db	0.8 db	10% Nominal
X	Gas	500 Kw	500 W	0.2 db	1.0 db	
	Ferrite	1 Mw	1 Kw	0.3 db	0.9 db	
Ku	Gas	150 Kw	150 W	0.2 db	1.0 db	
	Ferrite	150 Kw	150 W	0.3 db	0.9 db	
Ka	Ferrite	75 Kw	75 W	0.3 db	1.1 db	4% Nominal

All Microwave Associates duplexers incorporate low-loss, long-life, receiver protectors which guarantee crystal protection over wide temperature ranges and under extreme environmental conditions.

*The duplexer receiver loss includes the loss due to receiver protector TR tubes..

At each frequency band of the microwave spectrum, Microwave Associates has devices for efficient switching of high power.

MICROWAVE ASSOCIATES, INC.

BURLINGTON, MASSACHUSETTS

Western Union FAX-TWX: Burlington, Mass., 942 • BRowning 2-3000

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RF
PROJECT ENGINEERS
SENIOR DESIGN ENGINEERS
VHF-UHF
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Positions now open for engineers experienced in management of radio frequency projects, and for engineers experienced in radio frequency design. Our long range programs in lunar and interplanetary communications offer challenging assignments in an academic atmosphere.

Current projects include advanced development of precision radio tracking systems, digital telemetry and command systems, and terminal landing instrumentation.

Minimum B. S. degree and five years related design experience required. 10 to 15 years desired.

Immediate "on lab" interviews arranged for qualified applicants.

Send resume and qualifications today to

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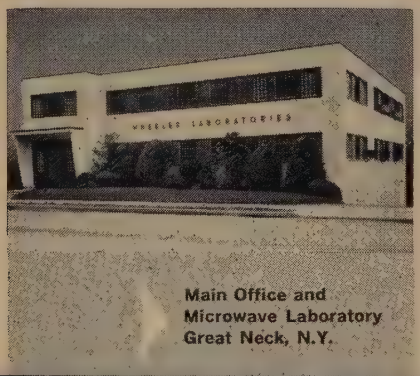

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Microwave Laboratory
Great Neck, N.Y.

In the field of microwave engineering, Wheeler Laboratories occupies a unique position as an industrial laboratory devoted exclusively to consulting and development.

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Antenna Laboratory
and Test Range
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As a service to many prominent laboratories and manufacturers, WL designs radar and communication antennas, waveguide components, and microwave assemblies. Your inquiries are invited.

Harold A. Wheeler
and
Engineering
Staff

WL

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Industry News

(*Continued from page 34*)

WESTINGHOUSE NAMES ALDRICH TO NEW POST

The Westinghouse Electronic Tube D vision, Elmira, N.Y., named Donald Aldrich to a newly created post as ma ager of manufacturing and engineerin for microwave tubes, it was announced Henry F. Frailey, power tube operatio manager.

Mr. Aldrich has served with division since 1952 in applications a sales product engineering. He joine Westinghouse graduate student progra in 1945 and was assigned to the Ele tronic Control Division and researc laboratories prior to 1952.

A graduate of the University of Mich gan, Mr. Aldrich received his MS degr from Carnegie Institute of Technolog He has been awarded several patents, h co-authored technical papers, and is member of the IRE and Sigma Xi pr fessional societies.

— m w j —

SYLVANIA PLANS NEW LABORATORY

Sylvania Electronic Systems, Waltha Mass., a division of Sylvania Electr Products Inc., today announced plans f a new Applied Research Laboratory faci ity and a new headquarters building, eac totalling approximately 45,000 squa feet, on a 55-acre site adjacent to prese division facilities in Waltham. Sylvan is a subsidiary of General Telephone Electronics Corporation.

Expansion has been necessitated by t division's rapid growth and by anticipat future growth of the division within t electronics field, according to Hen Lehne, a senior vice president of Sylvan and general manager of Sylvania El tronic Systems.

The modern buildings will be locat south of Winter street in Waltham, a proximately one-half mile west of the d vision's 160,000-square-foot Waltham L oratories and present 30,000-square-fo

(*Continued on page 60*)

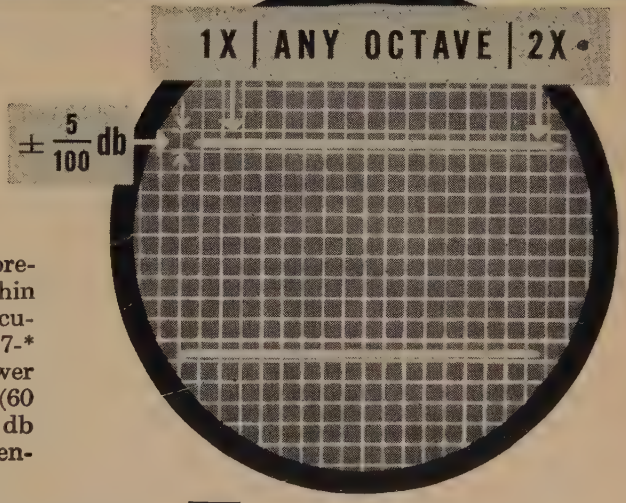
JERROLD

PRECISION SWEEP FREQUENCY GENERATOR model 707-*

5/100 db

ULTRA FLAT

Featuring...variable-rate, all-electronic sweep with plug-in oscillators covering 2 to 265 mcs.



The ultra flat sweep generator model 707-* is a precision instrument with an rf output that is flat within ±5/100 of a db over highest single octave. Particularly adaptable for use with an X-Y plotter, the 707-* features: plug-in oscillator heads; high output power (+20 dbm below 150 mcs.); variable sweep rate (60 per sec. to 1 per 2 min.); and harmonics down 40 db over highest single octave (down 30 db over the entire range).

*Order Model 707-1, 2, or 3 shipped respectively with oscillator heads H-71 (4-100 mcs.), H-72 (12-220 mcs.), H-73 (2-50 mcs.) **$795.00 each**

Model 707-4 shipped with H-74 (any single octave 2-265 mcs.) special order..... **$845.00 each**

Additional oscillator heads for any model 707

H-71, H-72, and H-73..... **$250.00 each**

H-74 special order..... **$275.00 each**

Write for catalog and technical Newsletter series on Measurements By Comparison using sweep frequency techniques. Prices and data subject to change without notice.

HIGH
output power—
+20 dbm

WIDE
sweep width—1% to
over 120% of c.f.

FLAT
output—±.05 db over
the highest octave

JERROLD

ELECTRONICS CORPORATION, Industrial Products Division
Dept. ITE-31 The Jerrold Building, Philadelphia 32, Pa.
Jerrold Electronics (Canada) Limited, Toronto
Export Representative: Rocke International, New York 16, N. Y.

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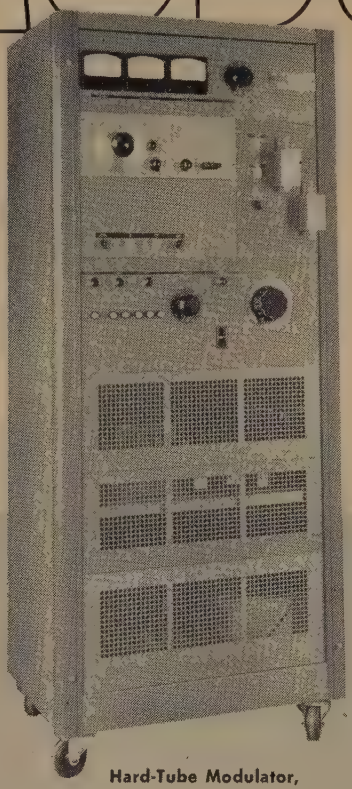
MANSON CUSTOM ENGINEERING IN MODULATORS

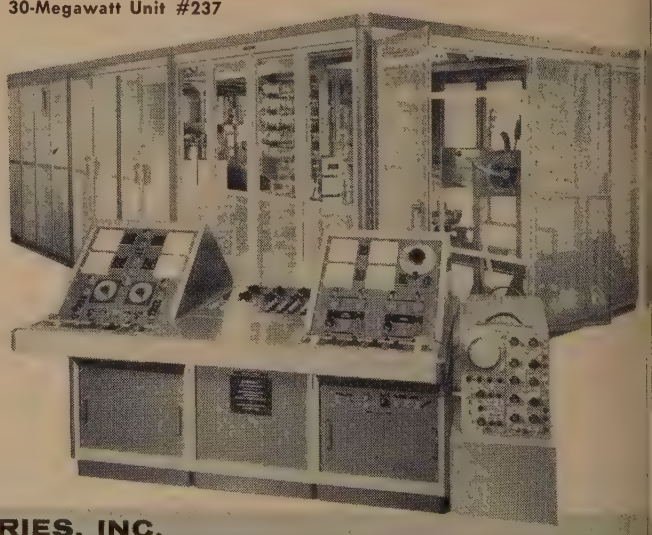


Hard-Tube Modulator,
350-Kilowatt Unit #240

- **POWER (peak):** 350 kilowatts
- **VOLTAGE (peak):** 17 kilovolts
- **CURRENT (peak):** 20 amps.
- **PULSE WIDTHS:** 1.0 to 10.0 microseconds, continuously variable
- **PULSE REPETITION FREQUENCY:** 20 to 10,000 pps, continuously variable, internally controllable by means of a built-in audio oscillator. In addition, a trigger input jack allows modulator to be operated from an external trigger source, at lower repetition frequencies.
- **MAXIMUM AVERAGE POWER:** 1400 watts
- **T.U.T. FILAMENT SUPPLY:** 0 to 15 volts AC @ 10 amps.

Advanced engineering at modest cost is Manson's outstanding achievement in the field of pulse techniques. If you have a problem touching on this field, call for MANSON CUSTOM ENGINEERING to help you solve it . . . it may be the most important help you have ever had!

Soft-Tube Modulator,
30-Megawatt Unit #237



- **POWER (peak):** 30 megawatts
- **VOLTAGE (peak):** 200 kilovolts into 1300 ohms
- **CURRENT (peak):** 150 amps.
- **PULSE WIDTHS:** ½, 1, 2, 4, 6 and 8 microseconds, measured at 90% voltage points
- **PULSE REPETITION FREQUENCY:** 50 to 1800 pps, continuously variable with higher PRFs at reduced power
- **MAXIMUM AVERAGE POWER:** 60 kilowatts
- **MONITORING:** Current-viewing resistor for T.U.T. primary; capacitance voltage dividers for viewing (1) primary of auxiliary pulse transformer, (2) primary of T.U.T., (3) secondary of T.U.T. and (4) grid drivers to thyratrons

MANSON manson **LABORATORIES, INC.**

375 FAIRFIELD AVENUE, STAMFORD, CONNECTICUT • DAvis 5-13

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At The Ramo-Wooldridge Laboratories... integrated programs of research & development of electronic systems and components.

The new Ramo-Wooldridge Laboratories in Canoga Park provide an environment for creative work in an academic setting. Here, scientists and engineers seek solutions to the technological problems of today. The Ramo-Wooldridge research and development philosophy places major emphasis on the imaginative contributions of the members of the technical staff. ■ There are outstanding opportunities for scientists and engineers. *Write* Dr. Richard C. Potter, Head, Technical Staff Development, Department 25-E.

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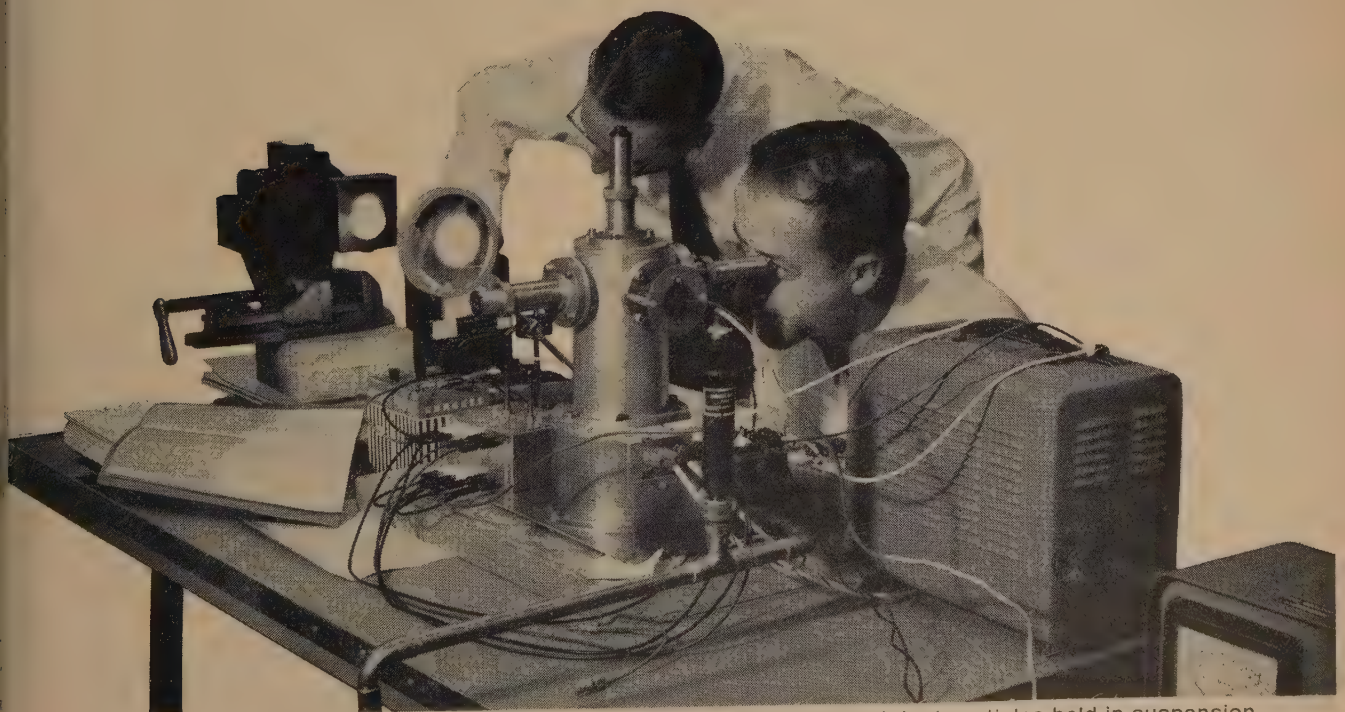

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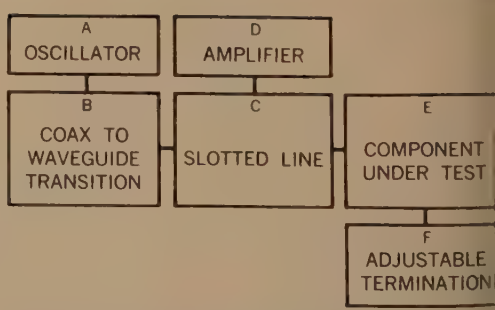

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In 1952 he joined the Raytheon Company and was engaged in the design of microwave components for missile and radar systems. He left Raytheon in 1954 for a two year military tour of duty as an Ordnance Engineer at Aberdeen Proving Grounds in the Army's Scientific and Professional Personnel Program.

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He joined Sylvania in 1951 and has been engaged in microwave tube, maser, and parametric amplifier research. Since 1956 Mr. Harrison has been a member of the Submillimeter Wave and Maser Section.

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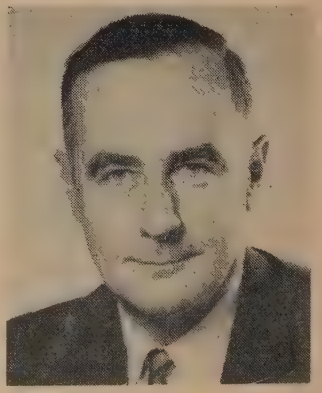

ERTRAM G. RYLAND attended Stanford University where he received the dees of B.S. in E.E. in 1947, M.S. in E.E. in 1948, and Degree of Engineer in 1954.

After being employed by the General Electric Commercial and Government quipment Division at Syracuse, N.Y., Mr. Ryland transferred to the GE Applicaons Engineering Department. In 1951 he returned to Stanford University as a search associate in their Electronic Research Laboratory.

Mr. Ryland rejoined General Electric in 1955 at their Microwave Laboratory, lo Alto, Cal., as a project engineer on a 15kw S-band klystron. Following this he as appointed manager, Electron Tube Design, and then assumed responsibility for e research and advanced development of all of the klystron programs.

In 1959 Mr. Ryland became director of Engineering, Raytheon Microwave and wer Tube Division, and manager of the Spencer Laboratory.

He is a member of Sigma Xi and IRE and was on a sub-committee of JETEC.

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Introduction

The measurements of microwave impedance and the Q of solid-state diodes has become increasingly important since the advent of the parametric amplifier. A new method of measuring the Q of such a diode, Q_d, has recently come into rather general use; the purpose of this paper is to explain it and to show its validity.

Recent publications[1,2] have dealt with methods of measuring parametric diode impedance. The semiconductor diode with its cartridge is usually embedded in a transmission line which may be preceded by a microwave impedance transformer and followed by a short circuit or a matched load. Normalized impedances are measured by standard slotted line techniques. The problem is to find the absolute value of the impedance of the semi-conductor material itself, taking into account various impedance transformations occurring in the rest of the cartridge and connecting transmission line system. In order to establish an absolute impedance level, it is necessary to utilize resistive standards or TEM waveguides of known characteristic impedance. In the measurement of diode Q_d to be treated, the problems and equipment are similar except that it is not necessary to establish an impedance level. Since Q_d is essentially a ratio of reactance to resistance, it can be related to normalized impedance measurements made with a slotted line.

Before going into the specifics of this measurement, an alternative method of measuring Q_d based on the well known cavity Q measurements should be noted. This method essentially involves making measurements with and without the diode loading a cavity. It is believed that the method of measuring Q_d described in this paper is comparatively simple in the experimental procedure, has less involved equipment requirements, and detects diode series resistance changes in addition to Q_d.

*Formerly Sylvania Research Labs.

Diode Equivalent Circuit and Q_d

The usual circuit representation of a parametric diode is shown in Figure 1. It is assumed in obtaining this representation that the effective electric field lines are essentially in the axial cartridge direction and that the microwave environment outside the cartridge has negligible effect on the direction of these fields. In this figure, only the semiconductor material is considered and the impedance corresponding to the rest of the diode cartridge circuitry is omitted. It consists of a resistance R_d in series with a parallel combination of a voltage-sensitive small signal capacitive reactance X_d, and a shunting resistance R_p. In ordinary parametric amplifier operation, the diode is reversed or negatively biased and, for the range of applied voltages, R_p is so large compared

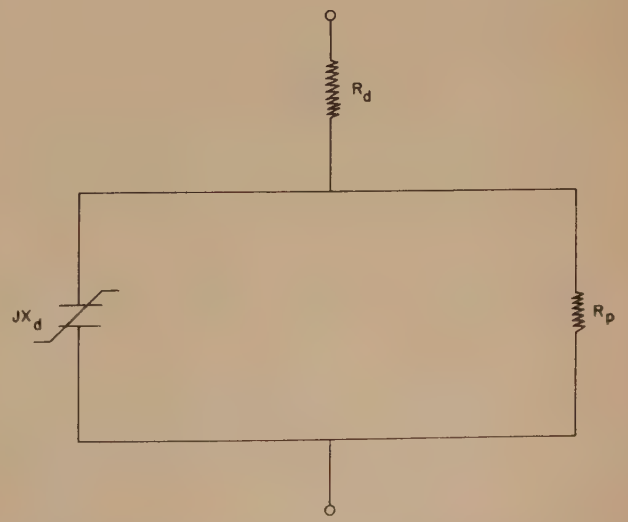

Figure 1 — Equivalent circuit of a parametric diode.

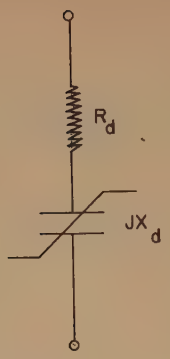

Figure 2 — Simplified equivalent circuit of a parametric diode for reversed bias.

to $|X_d|$ that the equivalent circuit can be simplified to that shown in Figure 2. It should be noted here that the series resistance R_d is substantially constant and independent of diode bias for all negative operating bias voltages and for a small range of positive bias voltages whereas X_d is a voltage-sensitive quantity. The diode Q_d is defined by

$$Q_d = \frac{-X_d}{R_d} = \frac{1}{\omega R_d C_d} \qquad (1)$$

where

$\omega = 2\pi f$ = frequency in radians per second
X_d = negative capacitative reactance

and is, for a given frequency, a function of bias.

Equipment Requirements

The equipment necessary for the measurement of Q_d consists of a signal generator, a slotted line (and standing wave detector), an ideally lossless variable transformer, and an ideally lossless diode cartridge holder. All these devices are connected in series as shown in Figure 3. The diode cartridge holder should be so constructed that the dc bias lead does not provide an r-f leakage path to the outside. The diode cartridge is ideally lossless except for the semiconductor material itself. As part of the procedure, the semiconductor material must be effectively replaced by a highly conductive material, thus effectively creating a required short circuit. One way to make this short circuit is to use a diode cartridge identical to that under test except that the semiconductor wafer is made highly conductive by a metal film.

One practical coaxial waveguide setup consisted of a double-stub tuner for the variable microwave transformer and a commercial coaxial diode cartridge holder altered so that the dc bias connection is not a microwave leakage path. Another rectangular waveguide system used an

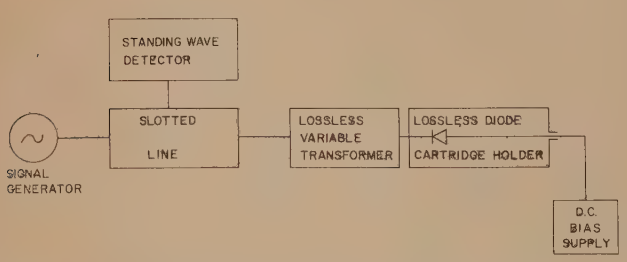

Figure 3 — Equipment Used for the Q_d measurement.

E.H. tuner for the microwave transformer and a commercial waveguide diode cartridge holder. Alterations were made to eliminate the r-f leakage path along the bias connection by shunting the BNC output connector with a large capacitor.

Measurement Procedure

The measurement procedure can be summarized as follows:

1. The input microwave power level is adjusted to such a level that the dynamic capacitance swing is small compared with the static capacitance at the particular diode bias used. One way to accomplish this in practice is to set the diode bias at zero, then adjust the microwave power so that the change in dc current is small when the r-f power is turned on.

2. The variable microwave transformer is adjusted so that a match is measured at a reference bias[3] of zero.

3. At various negative and positive biases[4] the corresponding normalized impedance is measured with respect to an arbitrarily chosen plane as the reference plane. These measurements plot on the Smith chart as a portion of a circle whose diameter is the same as that of the $R/R_o = 1$ circle as shown in Figure 4.

4. The semiconductor material in the diode is then replaced by an effective short circuit. The normalized impedance is measured using the same reference plane chosen earlier. This point is plotted on the Smith chart as shown in Figure 4. (Often it is convenient to choose the position of a standing wave minimum obtained with the short circuit as the reference plane). One way to achieve an effective short circuit is to substitute for the diode cartridge the short circuited cartridge mentioned earlier. Another way to accomplish this is to plot the normalized impedance of the diode for a range of positive biases. It has been found that, for silicon junction diodes, the semiconductor impedance tends to go to zero for positive

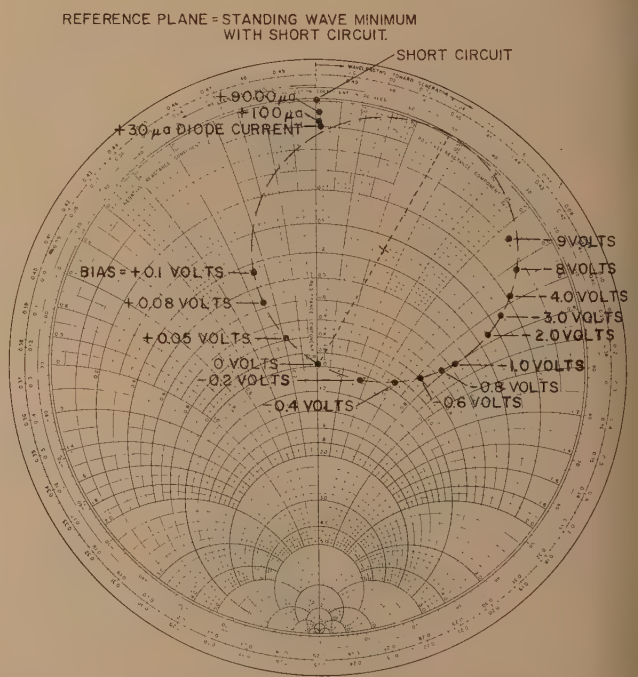

Figure 4 — Data plot on Smith chart.

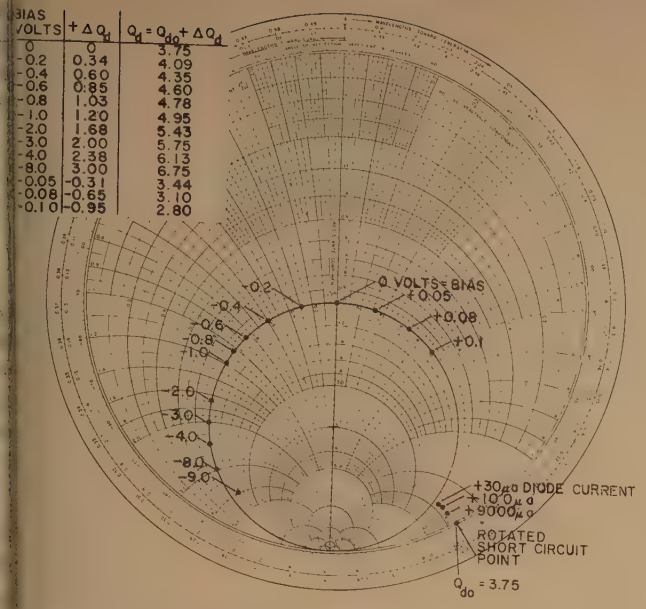

Figure 5 — Rotated data plot.

biases. Typical normalized impedance points, labeled with the dc diode current, are shown in Figure 4. In the case of point-contact gallium arsenide diodes, experience has shown that the diode dc currents exceed a permissible maximum much before an effective short circuit point is reached and the former shorted cartridge method is preferable.

5. The section of the circle plot around the center of the Smith chart is then graphically rotated so that it coincides with the $R/R_o = 1$ circle as shown in Figure 5. The short circuit point is similarly rotated through the same angle. (Note that the normalized impedance points taken to establish the short circuit point fall on a constant reactance line in this plot.)

6. The normalized reactance of the rotated short circuit point which is identically the Q_{do} of the diode at the zero bias point is then read. The Q_d for any bias point falling on the $R/R_o = 1$ circle can be found by adding to the zero-bias Q_{do} the negative of the normalized reactance,

$$\Delta Q_d = -X/R_o \qquad (2)$$

read off the corresponding point on the $R/R_o = 1$ circle. Thus,

$$Q_d = Q_{do} + \Delta Q_d \qquad (3)$$

A table illustrating results is given in Figure 5. For data points that do not fall on the $R/R_o = 1$ circle because R_d begins to vary, the Q_d may also be found. An example of such a point is the -9 volt bias point in Figures 4 and 5. To obtain Q_d for this point, first divide the Q_{do} of the normalized resistance corresponding to this point as plotted in the rotated data plot. Then,

$$Q'_{do} = \frac{Q_{do}}{R/R_o} \qquad (4)$$

Next divide the negative of the normalized reactance by the normalized resistance of the point, giving

$$\Delta Q'_d = \frac{X/R_o}{R/R_o} \qquad (5)$$

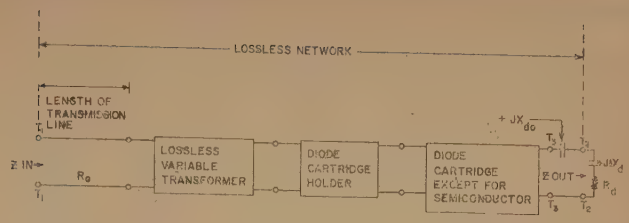

Figure 6 — Lossless network for measuring Q_d of a diode with a variable bias semiconductor reactance of $X_{do} + \Delta X_d$ where X_{do} is the zero bias reactance.

Then at this point

$$Q_d = Q'_{do} + \Delta Q'_d \qquad (6)$$

Analysis of the Method of Measurement

The analysis of the Q_d measurement starts with a consideration of the input-output impedance relation for a lossless network. This relation is

$$Z_{in} = \frac{A\,Z_{out} + B}{C\,Z_{out} + D} \qquad (7)$$

where A and D are real and B and C are imaginary.[5] For the Q_d measurement, the network is assumed to be as shown in Figure 6 between T_1 and T_2; that is, the lossless network includes a length of input transmission line of characteristic impedance R_o, a lossless variable transformer, a diode cartridge holder, and all of the reactive impedance of the diode cartridge including the zero-bias capacitive reactance of the semiconductor, but excluding the series resistance of the semiconductor. Under these conditions, step (2) in the measurement procedure requires that

$$R_o = \frac{A\,R_d + B}{C\,R_d + D} \qquad (8)$$

In order to establish the length of input transmission line or the input reference plane for which the data points in step (3) of the measurement procedure would fall on the $R/R_o = 1$ circle of the Smith chart, consider the condition where $Z_{out} = 0$. It follows from (7) that

$$Z_{in} = B/D \qquad (9)$$

and Z_{in} is purely reactive with a value between plus and minus infinity depending on the position of the input reference plane. For the length of transmission line that gives $Z_{in} = 0$ for $Z_{out} = 0$, it follows that

$$B = 0 \qquad (10)$$

because D is normally finite. Since in (8) R_o, R_d, A and D are real, and C is imaginary, it is necessary that

$$C = 0 \qquad (11)$$

Therefore, for this length of input transmission line, or at the input reference, plane T_1,

$$\frac{Z_{in}}{R_o} = \frac{Z_{out}}{R_d} \qquad (12)$$

The input impedance seen at T_1 for a semiconductor diode in the range of bias voltages where R_d is constant is

$$\frac{Z_{in}}{R_o} = 1 + j\frac{\triangle X_d}{R_d} = 1 - j\triangle Q_d \tag{13}$$

Hence for this choice of input terminal plane the impedance points on a Smith chart plot on the $R/R_o = 1$ circle where $X/R_o = \triangle X_d/R_d = -\triangle Q_d$. The Q at zero bias, Q_{do}, can be determined from the input impedance at T_1 corresponding to a short circuit at port T_3 which, from Figure 6, means replacing the semiconductor by a short circuit. Mathematically, this is equivalent to an impedance $Z_{out} = -j\ X_{do}$ across port T_2 since this will just compensate for $+\ j\ X_{do}$ between T_2 and T_3.

Equation 12 can then be re-written in the form

$$\frac{Z_{in}}{R_o} = \frac{-j\,X_{do}}{R_d} = +j\,Q_{do} \tag{14}$$

Therefore, the total Q_d can be found from (3) of step 6 in the measurement procedure.

In similar manner, it can be shown that Equations (4), (5), and (6) follow from the same analysis. In practice it is not necessary to establish the reference plane T_1. A measurement is made with an arbitrary reference plane, and the circle plot is then rotated to establish T_1.

References and Notes

1. M. C. Waltz, "A Technique for the Measurement of Micr wave Impedance in the Junction Region of a Semiconduct Device," *the microwave journal*, Vol. 2, No. 5, May 195 pp. 23-27.
2. R. P. Garver and J. A. Rosado, "Microwave Diode Cartrid Impedance," Diamond Ordnance Fuze Labs., Document T 721, July 6, 1959.
3. The choice of the reference bias where the transformer adjusted for match is arbitrary as long as the bias is anywhe in the range where the series resistance is constant.
4. In the measurement at positive biases, care should be tak to limit the dc forward diode current to rated values for t diode.
5. E. L. Ginzton, "Microwave Measurements," McGraw Hi 1957, pp. 278-280.

Acknowledgments

The author is indebted to Dr. G. E. Weibel for su gesting a simplified approach that led to the analy described, and to Shirley W. Harrison for making t measurements.

MICROWAVE RADIOMETRY

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PART II

Instrumentation

Early investigators in the field of microwave radiometry employed conventional superheterodyne receivers. For example, Southworth, in his report on microwave radiation from the sun,[6] employed a double detection receiver designed to work at wavelengths in the centimeter region. The input signal power levels, resulting when radiometer observations are made, are so low, however, that they are frequently below the noise level of the receiver, even where the receiver noise figure is as satisfactory as it can be made through the use of masers or parametric amplifiers. In 1945, R. H. Dicke,[2] at the MIT Radiation Laboratory, developed a specialized type of radio receiver which has since become accepted as the standard radiometer receiver. In this receiver, the inherent receiver noise is cancelled out by a process involving a comparison of the noise power received from the antenna with the noise power from an attenuator inserted in the antenna line. This attenuator, which is matched to the line for all depths of insertion, effectively terminates the line when completely inserted, and prevents energy from the antenna from reaching the input of the receiver. Under these conditions, the input to the receiver consists of the sum of the inherent receiver noise and the noise due to the reference attenuator. When the attenuator is removed from the line, the input to the receiver consists of the sum of the receiver noise and the noise signal picked up by the antenna.

The antenna line is connected to the input of a more or less conventional superheterodyne receiver, including a mixer, a 30 megacycle i-f amplifier and a diode second detector. When the attenuator is inserted in the antenna line, it is seen that the diode output is proportional to the sum of the noise emitted by the attenuator and the receiver noise. When the attenuator is not in the antenna line, the diode output is the sum of the noise signal picked up by the antenna and the inherent receiver noise. It would evidently be possible to make a comparison between these two values of the output current of the detector, inserting the attenuator into the antenna line and removing it manually. The difference between these two readings would then indicate the difference between the noise power picked up by the antenna and the noise power generated by the attenuator, eliminating the inherent receiver noise.

In practice, the attenuator is inserted into and removed from the antenna line by a motor driven mechanism at a frequency of 30 cycles per second. The output of the diode detector is, therefore, a 30 cycle wave, the amplitude of which is a function of (antenna noise + receiver noise) minus (reference attenuator noise + receiver noise) = antenna noise minus reference attenuator noise.

This 30 cycle wave is impressed on a bandpass amplifier tuned to 30 cycles, and after amplification is rectified in a phase-sensitive rectifier, the reference phase being provided by a generator rotating synchronously with the reference attenuator. The output of the phase-sensitive rectifier, after passing through a low-pass filter, is presented on a milliameter, which is calibrated to read the difference in temperature between the antenna and the reference attenuator, in °K.

This system effectively cancels the inherent receiver noise, and makes it possible for the receiver to indicate, with a considerable degree of precision, temperature differences proportional to noise levels which are considerably smaller than the inherent noise of the receiver. It is to be noted, however, that complete cancellation of the inherent receiver noise will occur only if the level of this noise does not vary throughout the entire modulating cycle. This condition is not satisfied exactly, due to the statistical nature of the receiver noise and signal. In effect, the receiver noise averaged over a finite time interval is sub-

tracted from that of a preceding time interval. Since the noise levels during these intervals are not exactly equal, a small quantity of receiver noise remains after each subtraction, and this residual quantity of noise appears in the form of fluctuations in the output meter.

These fluctuations limit the maximum sensitivity that can be attained with this type of receiver, as it is evident that variations in the temperature of an observed emitter cannot be readily measured if they are less than the equivalent temperature of the fluctuations. We may say, therefore, that the minimum variation measurable is equal to the temperature equivalent of the fluctuations. This is not a hard and fast rule, as physiological factors enter into the measurement, and the skill of the individual operator may result in sensitivities greater than, or less than, those indicated by this relationship, particularly if care is taken to integrate the results of the measurement over a long period of time. Nevertheless, the temperature equivalent of the noise fluctuations is seen to be an adequate index to the sensitivity, and in practice gives satisfactory results.

Dicke,[7] has derived an expression for the root-mean-square temperature fluctuations in the output meter as a function of the system parameters (assuming a critically damped filter),

$$\triangle T = \xi T_a F \left(\frac{b}{\triangle f}\right)^{\frac{1}{2}}, \qquad (40)$$

where

F = over-all receiver noise figure expressed as a power ratio.

$\triangle f$ = receiver i-f bandwidth in cycles per second.

b = bandwidth of low-pass filter in cycles per second.

T_a = temperature of modulating wheel, assumed to be the standard reference temperature T_o = 290° K in this case.

$\triangle T$ = RMS temperature fluctuations of the output meter in degrees Kelvin.

ξ = a constant.

In turn, in a receiver of the type under consideration, the over-all receiver noise figure may be shown to be in accordance with the following expression:

$$F = L_c(t_c + F_{i\text{-}f} - 1), \qquad (41)$$

where L_c is the conversion loss of the crystal mixer expressed as a power ratio greater than unity, t_c is the ratio of the noise power available from the crystal to the available noise power from a resistor ($KT_o\triangle f$), at the reference temperature, 290°K., measured at the i-f frequency used; $F_{i\text{-}f}$ is the intermediate frequency amplifier noise figure.

In applying these relations, all values are expressed as power ratios. Without an r-f amplifier, it is found that the crystal mixer is controlling in determining the noise figure of the receiver. For example, a 1N26A crystal at K band has a maximum conversion loss equivalent to a power ratio of 5.6, and a maximum noise power ratio of 2.0. The i-f amplifier noise figure may be typically 1.4. Substituting these values in equation (41), we obtain a practically realizable receiver noise figure of:

$$F = 5.6\ (2.0 + 1.4 - 1) = 13.4. \qquad (42)$$

This value of noise figure is according to the standard IRE definition. However, if a superheterodyne receiver is used that is equally receptive to image and signal band input noise, the *effective* noise figure for radio astronomy work is one-half that given by equation (41) or (42). Thus in this example, the value of F to be used in equation (40) is 1/2 x 13.4, or 6.7. If only the signal band is receptive, the value 13.4 would be used.

The constant ξ has been studied at considerable length by various investigators,[7, 8, 9, 10] and a variety of values for this constant has been obtained, ranging from

$\frac{\pi^{3/2}}{8} = .69$ (Dicke)[7] to 5.65 (Strom)[10] depending on

the shape of the passbands, and other factors. Radio astronomers working in the field have adopted the practice of computing a value of ξ which suits their particular equipment. This value generally is found to be in the vicinity of 1.0. Figure 5 shows the relation between the RMS temperature fluctuations of the output meter in degrees centigrade as a function of the noise figure of the receiver, and the bandwidth of the low-pass filter in cycles per second, in accordance with equation (40). In preparing this figure it has been assumed that the I.F. bandwidth is fixed at 8.0 mc per second, the modulator wheel is assumed to be at room temperature, 290° K and ξ is 1.0.

It will be observed from this figure that, if a receiver noise figure of 8:1 be assumed, the RMS temperature fluctuations of the output meter will vary from approximately 0.083° K to approximately 0.83° K, over a range of low-pass filter bandwidths from 0.01 to 1.00 cycles per second. It is thus evident that with conventional receiver designs it may be expected that temperature varia-

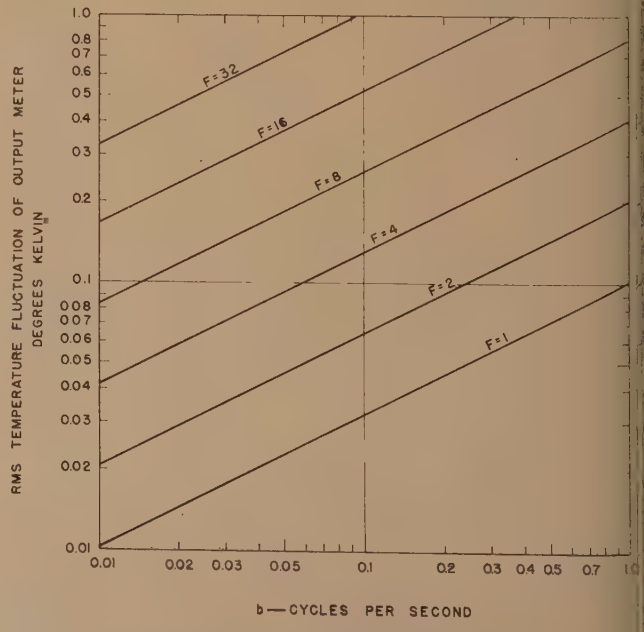

Figure 5 — RMS temperature fluctuations of output meter vs low-pass filter bandwidth. (i-f bandwidth 8.0 mc)

ons of the order of 0.08° K can be detected. This mperature variation can be shown to be equivalent to power variation of 0.88 x 10^{-17} watts.

From the foregoing analysis it would appear that the nsitivities of conventional Dicke superheterodyne type diometers are already satisfactory. However, so little wer is received from some celestial objects (particularly anets subtending a small fraction of the antenna beam-idth) that many problems in radio astronomy demand nsitivities considerably better than tenths of a degree elvin. Equation (40) shows that with superheterodyne ceivers the sensitivity can be improved by increasing e integration time (in other words, by reducing the w-pass filter bandwidth b) or by increasing the i-f ndwidth $\triangle$f. A reduction in noise figure is also effec-ve in improving the sensitivity. Long integration times p to 100 seconds) have actually been employed in some perheterodyne radiometers, to obtain sensitivities slightly ss than 0.1° K. Low noise traveling-wave amplifiers, asers and parametric amplifiers can also be incorporated the r-f circuits with the objective of reducing the ise figure.

Tuned r-f receivers retaining the Dicke r-f switching heme and employing low-noise traveling-wave tubes ve recently been developed.[11,12] These receivers, by iminating the i-f amplifier and increasing the integra-on time, not only reduce b, but also increase $\triangle$f by veral orders of magnitude, resulting in predicted sensi-vities limited by statistical noise fluctuations of the der of 0.01° K. As a result a new consideration comes to play; fluctuations in the gain of the receiver. In der to reduce the deleterious effects of such fluctuations the sensitivity an artificial noise source is introduced the antenna circuit. The output of this noise source balanced against the noise received from the reference sistor in the absence of a signal. Under these condi-ons it can be shown that the effect of gain variations n be greatly reduced.

The analytical results of Strum, Drake and Ewen[11,12] ake an important contribution to improvements in mi-owave radiometers, particularly since their equations for aximum sensitivity include the noise due to gain fluc-ations which is not cancelled out by the modulating ocess.

Instead of a rotating eccentric attenuator, a fixed re-stor is used as the reference resistor. Switching from e antenna to the reference resistor is accomplished by eans of a ferrite switch. The use of a reference resistor akes it possible to regulate the temperature of the re-stor and therefore to operate this resistor at temperatures s or greater than room temperature. Their basic equa-on uses the expression "$F_e - 1$" in place of "F" in the icke equation (40). Conventionally, the expression "-1," of course, represents the noise contributions of e receiver itself and does not take into account noise ntributions from an artificial antenna load, as in the case Dicke. In the absence of noise injection into the an-na circuit, Drake and Ewen's expression (3) is there-re strictly valid for the case where the temperature of th the source and the reference resistor is near absolute ro. However, in the Strum, Drake and Ewen papers, e expression ("$F_e - 1$") is defined as the "equivalent stem noise," and this equivalent system noise is intended include the noise injected by the noise generator. There-

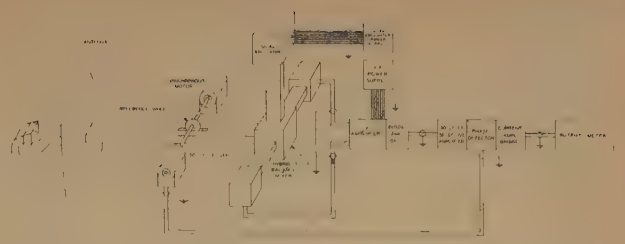

Figure 6 — Block diagram of Dicke superheterodyne radiometer.

fore, to relate the "equivalent system noise" of Strum, Drake and Ewen to the conventional noise figure F, we have $F_e - 1 = (F - 1) + \frac{T_a}{T_o}$, where F is the noise figure of the receiver itself, T_a is the ambient temperature of the reference resistor and antenna and T_o is the standard reference temperature, 290° K. In this system, the reference resistor may therefore be operated at any temperature, equal to the observed antenna temperature, and the minimum detectable temperature $\triangle$T is accurately represented by the equations in these references.

It is noted from Strum's paper that, in a superheterodyne, in view of the broad band noise source being observed and the consequent reception of the image response, the effective noise figure is ½ (3 db less than) the noise figure as given by the standard IRE definition.

Figure 6 is a block diagram of the Dicke superheterodyne radiometer showing the principal components of the system. The received energy is collected by the parabolic antenna at the left side of the diagram and concentrated on the antenna feed, which in this case consists of a horn. Entering the waveguide, the radio frequency power passes by the modulator, where it is modulated by the reference wheel or attenuator at a rate of 30 cycles per second. The mixer employed is of the balanced type, and includes a hybrid T waveguide assembly, which is adapted to prevent local oscillator power from reaching the attenuator, assists in reducing the amount of noise delivered by the local oscillator into the intermediate frequency amplifier and prevents the received signal from being absorbed by the local oscillator coupling line.

In the type of K-band radiometer developed and constructed by McCoy et al,[1] a klystron local oscillator operating at a frequency of approximately 24,000 megacycles is employed. The intermediate frequency amplifier is tuned to a frequency of 30 megacycles per second, and has a bandwidth of about 8 megacycles. The overall amplifier gain is about 90 db. This amplifier is followed by a conventional 6AL5 diode detector adapted to rectify the modulated noise signal and restore the 30-cycle modulating wave.

The 30-cycle selective amplifier has a gain of approximately 35 db and a bandwidth of 5 cycles to half-power points. This 30-cycle amplifier is followed by a phase detector which consists of a pair of 6SJ7 tubes, the control grids of which are driven push-pull by the output of the 30-cycle amplifier. The suppressor grids of these tubes are driven in phase by the 30-cycle reference voltage in order to produce phase detection. The output of the phase detector is delivered through a low-pass filter and

Figure 7 — Radiometer and equatorial mount.

current amplifier bridge to the indicating output meter.

Figure 7, shows a view of an experimental radiometer adapted for celestial observation and provided with an equatorial mount, as reported by McCoy et al.[1] Later, equipment of this type was developed into a sun tracker, or "radio sextant," the original S-band model of which is shown in Figure 8.

Calibration

Equation (29) is a general expression relating the received input power to the temperature of the emitting body. In order to apply this relationship to observations made with practical radiometer equipment, it is necessary to develop the relation between the power received and the output meter reading. In considering this phase of the matter, we first observe that the indicated output voltage E_o is a linear function of the amplitude, E_{30}, of the 30-cycle wave appearing at the output of the diode second detector:

$$E_o = g_a E_{30} \ , \qquad (43)$$

where g_a is the over-all voltage gain of the audio section, including the phase detector.

Now it is evident that the amplitude E_{30} is dependent on the difference between the diode output voltage E_R at the moment when the attenuator is completely withdrawn from the antenna line, and the diode output E_A at the moment when the attenuator is completely inserted in the waveguide. This difference in voltage represents twice the amplitude of the wave, so that we have,

$$E_{30} = \frac{E_R - E_A}{2} \ . \qquad (44)$$

In turn, since the diode is a linear detector, its outp voltage is proportional to the square root of its inp power and we may write:

$$E_{30} = \frac{\sqrt{g_b^2(P_R + N)} - \sqrt{g_b^2(P_A + N)}}{2}$$

$$= g_b \left[\frac{\sqrt{P_R + N} - \sqrt{P_A + N}}{2} \right],$$

(4

where g_b is the over-all voltage gain of the r-f and sections of the radiometer, $N = kT_o\triangle f(F-1)$ is inherent noise power of the receiver, and P_R and P_A the received antenna power and the reference resis (attenuator) power respectively. Then the indicated o put voltage is:

$$E_o = \frac{g_a g_b [\sqrt{P_R + N} - \sqrt{P_A + N}]}{2} .$$

(4

It is observed from this equation that the output in cation is not strictly a linear function of the receiv power. However, in the case of most measurements, w the exception of solar measurements, N is usually la with respect to either P_R or P_A. Under these conditio it can be shown that the expression in brackets is proximately a linear function of P_R, in accordance w the following relationship:

$$[\sqrt{P_R + N} - \sqrt{P_A + N}] = \frac{P_R - P_A}{2\sqrt{N}} .$$

(4

Substituting this relationship in equation (46), we hav

$$E_o = \frac{g_a g_b}{4} \cdot \frac{P_R - P_A}{\sqrt{N}} \ .$$

(4

In applying this expression, we now return to equati (29) and define the over-all antenna gain, Γ in acco ance with the following relationship:

$$\Gamma = \frac{1}{4\pi} \int_\Omega G(\theta, \phi) d\Omega \ ,$$

(4

so that equation (29) may be written, for convenien in the form:

$$P_R = \Gamma \, akT\triangle f \ . \qquad (5$$

We also observe that the power, P_A, received from attenuator is the power generated by the "Johns thermal noise of the disc, and is given by:

$$P_A = kT_a\triangle f \ , \qquad (5$$

where T_a is the ambient temperature of the disc.

Substituting the results of equations (50) and (51) in equation (48) and representing the over-all system gain $g_a g_b$ as γ, we obtain:

$$E_o = \frac{\lambda}{4} \cdot \frac{[\Gamma a k T \triangle f - k T_a \triangle f]}{\sqrt{N}}$$

$$= \frac{\gamma k \triangle f}{4\sqrt{N}} [\Gamma a T - T_a] . \tag{52}$$

The reading of the output meter is thus seen to be approximately proportional to the difference between the temperature of the observed source and the temperature of the reference attenuator. The output meter is now calibrated, by marking the dial, in such a way that it reads in degrees Kelvin, instead of volts, in accordance with the equation,

$$E_o = K T_i, \tag{53}$$

where T_i is the indicated temperature, and K is a calibrating constant representing the number of volts deflection per degree Kelvin indicated. Then

$$T_i = \frac{E_o}{K} = \frac{\frac{\gamma k \triangle f}{4\sqrt{N}}}{K} [\Gamma a T - T_a], \tag{54}$$

and if

$$K = \frac{\gamma k \triangle f}{4\sqrt{N}} \tag{55}$$

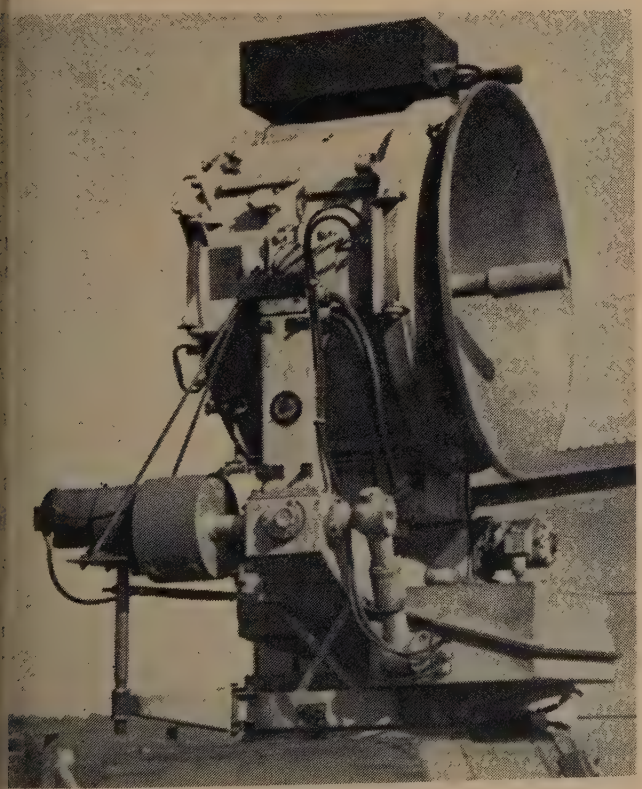

Figure 8 — Experimental model of radio sextant.

then the indicated temperature is

$$T_i = [\Gamma a T - T_a], \tag{56}$$

the required direct-reading relationship. In turn, the temperature of the body being observed is

$$T = \frac{T_i + T_a}{\Gamma a} \tag{57}$$

and it is seen that in practice this quantity is determined merely by adding the indicated temperature and the known temperature of the reference attenuator, and dividing by the product of the antenna gain and the absorptivity of the body being observed.

Under conditions of actual observation, although the antenna gain can be determined with good accuracy, the absorptivity is frequently a doubtful quantity. It is, therefore, convenient to employ the concept of "equivalent antenna temperature." This quantity is defined as the temperature, T_e, which would be assumed by a resistance connected in place of the antenna, in order to produce the observed reading. Returning to equation (50) it is seen that the thermal noise power generated by such a resistance is

$$P_R = k T_e \triangle f. \tag{58}$$

It can easily be determined, by substituting this quantity in equation (48) and carrying out the operations of equations (51) to (57) that the relationship between the temperature of the hypothetical resistance and the indicated temperature is

$$T_e = T_i + T_a. \tag{59}$$

It is thus seen that the equivalent antenna temperature is also the temperature of a hypothetical perfect black body, completely surrounding the antenna. Another useful concept is developed by substituting (59) in (57), to obtain

$$T = \frac{T_e}{\Gamma a}, \tag{60}$$

which shows that the actual temperature of any body is the equivalent antenna temperature, while it is being observed, divided by the product of the absorptivity of the body and the antenna gain.

In practice, the indicated temperature, T_i, may be either positive or negative, depending upon whether T_e is greater or less than T_a, the temperature of the reference attenuator.

Observations

Since the microwave radiometer is merely another instrument for making astronomical observations, like the telescope, the spectroscope, the bolometer, etc., results obtained by employing it for observational purposes are properly reported in connection with the particular objects observed. In view of the extensive development of radio astronomy in recent years, it is no longer possible

to present a full account of observational results in a paper of limited length. The following much-condensed outline of important events in the history of radio astronomy is, however, appended for the sake of completeness. Much of this information was obtained from Professor R. N. Bracewell's comprehensive collection of papers recently presented in Paris on the subject of Radio Astronomy.[20]

It may properly be said that this field of investigation started with the observations of Karl G. Jansky,[13] of the Bell Telephone Laboratories, in 1921, when he discovered that noise from the center of the galactic system could be detected at a frequency of 20.5 megacycles per second. Jansky's work was supplemented within the next several years by the work of Friis and Feldman,[14] and of Potapenki and Folland,[15] who also determined that radiation from extraterrestrial sources could be picked up by short-wave radio receivers.

Operating at a frequency of approximately 160 megacycles per second, Grote Reber,[16] in 1936, undertook an extensive program of observation of radio frequency radiation received from the plane of the Milky Way. Reber was able to localize a definite maximum in the level of cosmic noise received, in the direction of the center of the galaxy. Reber since expanded his program to a frequency of 480 megacycles per second, and at this frequency observed two maxima in the same galactic longitude.

G. C. Southworth,[6] of the Bell Telephone Laboratories, made the original observations at centimeter wavelengths during 1942 and 1943. He found that cosmic noise, as reported previously by Jansky[13] and Reber,[16] was not detectable at this frequency, but was successful in making rather careful comparisons between calculated and observed noise levels from the sun.

Hey, Phillips and Parsons,[17] in England, have made a survey of the distribution of cosmic noise at 65 megacycles per second and found a similar concentration of energy at the plane of the galaxy, and a similar location of the maximum in Cygnus.

Other early observers carried on similar investigations at relatively low frequencies ranging from 40 to 200 megacycles per second. More recently, as a result of a technical program established during World War II, higher frequencies have become available for this work, and, at the present time, radiometric receivers of the Dicke type, operating at microwave frequencies, have become more or less standard. This equipment was originally developed by Dicke for the purpose of making atmospheric absorption measurements in connection with radar propagation investigations. He has since been able to report[18] the results of observations of the sun and moon, taken by means of this equipment, through which he concluded that the effective black body temperature of the sun at a wavelength of 1.2 cm. is approximately 1.0 x 10^4° K. The effective black body temperature of the nearly-full moon was also found to be approximately 292° K. at this frequency.

Under the direction of W. W. Salisbury, the Research Division of the Collins Radio Company started a program of radiometric observations in 1947, involving the construction of a number of Dicke radiometers operating at wavelengths of 1.25, 1.83 and 10 centimeters. This equipment was used to study atmospheric absorption, and was also employed to determine solar and lunar temperatures. Observations of the lunar eclipses of April and October, 1949, revealed the surprising fact that the radio frequency radiation received from the moon does not alter appreciably in amplitude during a lunar eclipse. This fact is attributed to the low dielectric losses and good heat-insulating properties presumed to exist in the visible layers of the moon's surface[19,20] and to the fact that the moon's reflectivity at microwave frequencies is low. Under these conditions, the radiation detected originates at a layer considerably below the surface, which is presumed to consist of a loose layer of dust or volcanic ash, where the temperature is relatively constant. This result indicates that it may be possible in the future to use radiometer equipment to measure the temperatures of some of the cloud covered planets beneath their visible surfaces. Some of this work has already been done.[20-a]

Radio observations of an occultation of the Crab Nebula by the moon have been made at 3.7 mm. and indicate an atmosphere density on the moon within the limits of 2 x 10^{-13} and 6 x 10^{-13} atmospheres.[20-b]

Radiometer measurements of the dark side of Venus yield a temperature of 410°K ± 40% at 8.6 mm.[20-c] The result of another set of measurements, using a ruby maser at 3.37 cm. was 575° ± 10%[20-d].

Jupiter has been observed at 10cm. and at 3.18cm. At 10 cm. the average temperature was found to be 580° K with a variation from 860° to 390°. A temperature of 145° was indicated at 3.18 cm., contrasting with infrared measurements giving a temperature of 130° K[20-e]. The difference in apparent temperature is unexplained.

Although nonthermal radiation from planets does not properly fit the scope of this paper, it is interesting to note that radiation of this type has definitely been received from Jupiter, and probably from Saturn at 23.0 mc[20-f].

Considerable research has been carried on in various laboratories involving solar observations at centimeter wavelengths. The sun is found to have measurable radiation between the limits of 20 megacycles per second and 30,000 megacycles per second. Various investigators have concluded that radiations from the sun fall into two classes: first, those due to the "quiet sun," which appear to be due to the visible photosphere, and are almost exclusively the source of radiation at the higher frequencies: and, second, radiation due to the disturbed sun which becomes most evident when relatively low frequencies in the vicinity of 200 megacycles per second are employed.[21]

Radiation due to the disturbed sun occurs in bursts which are apparently associated with the corona and give radiation temperatures of the order of 10^9° K.

More recently, emission profiles of the inner corona, chromosphere, and photosphere have been measured at various wavelengths, including 8 mm., 3 cm., 20 cm., and 88 cm., leading to the derivation of models of the solar envelope.[20-g] The "slowly varying component" originating in active regions on the sun has also been investigated at 3 cm., 20 cm., 50 cm., and 88 cm., representing successively greater heights above the photosphere.[20-h]

A great deal of work has been done on solar radio bursts which have now been grouped in five classes, depending on duration, frequency, polarization, constancy of posi

n, and other characteristics. It has now been confirmed at Type II and Type III bursts are generated by rapidly ending disturbances which excite electromagnetic oscillions at various heights as they proceed. Ascension is o postulated in the case of Type IV and Type V bursts. e characteristics of the outer corona have been exsively investigated by observing a succession of occltations of the radio source in Taurus by the outlying gions of the corona.[20-i]

Perhaps the most spectacular result of the radio asnomy program has been the discovery of numerous dis-te galactic and extra-galactic sources of radiation at lio frequencies, some of which are associated with ible objects such as nebulae of various descriptions, d some of which apparently are located where nothing to be seen. In some cases these objects have been rered to as "radio stars," but in general, it now appears t they are nebular rather than astral in nature.[20-j] In rticular, a survey has been made at a wavelength of meters, and a concentration of sources has been found r the plane of the galaxy.[22] The array of helical ennas used in making this survey at Ohio State Unisity is shown in Figure 9.

Speaking of observations at radio frequencies in general, l including some types of radiation previously dissed, it appears that the following phenomena have en observed: [20-j]

1. Thermal or "black body" radiation from the sun.

2. Radiation associated with "bursts" from the sun, inding longitudinal plasma oscillations coupled by inogeneities, or by magnetic field effects, and Cerenkov liation. The exact mechanism of these bursts is still known, and much work remains to be done on the ject.

3. Thermal or "black body" radiation from the planets l the moon. Radiation of this type has a continuous ctrum and follows the "gray body" relationships deoped in the theoretical sections of this paper.

4. Radiation at 21 centimeters from atomic hydrogen uds, identified as of the H_I type. It is now affirmed t radiation of this type comes principally from spiral as of the galaxy. A line spectrum is produced, in which 21 centimeter wavelength is prominent.

ure 9 — 96-helix radio telescope antenna at the Ohio State University.

5. Nonthermal radiation from discrete sources and the galactic corona. The nature of this radiation is still not definitely agreed upon. It appears, however, that it is probably due to the motion of relativistic electrons following a helical path around magnetic lines of force. The spectrum is continuous due to inhomogeneities in the magnetic field, distribution of the velocity of the electrons and nonlinear effects. Radiation of this type is also referred to as "synchrotron," "magnetobremsstrahlung," "magnetic bremsstrahlung," "cyclotron," and "acceleration" radiation. It is also sometimes included in the class of "continuum" radiation, although the use of this word is somewhat questionable, since the radiation does not appear to be due to transitions from the continuum. Although the spectrum is continuous, the radiation differs from black body radiation in its spectral index, which may vary from 0.5 to 1.5. The spectral index is defined in accordance with the equation:

$$P(\nu) \propto \nu^{-x} \qquad (61)$$

where $P(\nu)$ is the power in a given bandwidth emitted at frequency ν and x is the spectral index.

6. Nonthermal radiation from the planets. Radiation of this type occurs in bursts like lightning strokes. An example is radiation received from Jupiter.

7. Thermal radiation from H_{II} sources, such as Cygnus X. It is now affirmed that these sources consist of fully ionized hydrogen clouds which produce emissions giving a continuous spectrum by means of transitions in and from the continuum.

Work on galactic radiation grew out of the original reports by Hey, Phillips and Parsons in 1946.[17] Later, it was found that radio sources of the type described by them abound not only in our own galaxies but in external galactic systems as well.

It is thought that the nonthermal sources in our galaxy are the remains of supernovas. In particular, the Crab Nebula in Cygnus is known to be the remnant of the supernova of 1054 A.D. Kepler's nova of 1604 A.D. lies in Ophiuchus and is now a "radio star." The nova of 1572 A.D., known as "Tycho's Nova," lies in Cassiopeia and is now a similar nonthermal source.

Some of the extra-galactic objects are extremely large, probably because they are associated with external galaxies. For example, the source Centaurus A, which apparently coincides with the nebula NGC 5128, has a length of 7.6° and a width of 2.3° at a distance of 750 kiloparsecs. (One parsec = 3.258 light years. One light year = 5.88×10^{12} miles.)

Radiation at 21 cm., originating from H_I clouds, is useful in determining the distribution of matter in the galaxy. An absorption line also occurs, of course, when such clouds intervene between the point of observation and an emitting source of higher temperature. Doppler frequency shifts indicate the velocities of the emitting or absorbing media, and from observations of velocity distribution, as reflected in the broadening of the spectrum of the received signal, depth and temperature can be deduced. The absorptivity gives the density. Utilizing these 21 cm techniques, almost complete maps of the galaxy to within 100 to 200 parsecs of the sun have been prepared, showing the distribution of H_I clouds, which presumably coincide in location with other diffuse matter, if any exists. Depth, temperature and distance are given where configurations have permitted the employment of absorption techniques.[20-j]

Acknowledgment

The author is indebted to Dr. D. O. McCoy of the Collins Radio Company for discussions and for permission to use much of the information included in Reference No. 1; to Dr. Carson Flammer of Stanford Research Institute for his appraisal of the physical values involved in some of the nonthermal interaction processes mentioned in the paper; to Professor Ronald N. Bracewell of Stanford University for general discussions of the subject of radio astronomy and for his permission to use Figures 1 and 2; and to Dr. Seymour Cohn and Dr. E. M. T. Jones of Stanford Research Institute for discussions of the problem of radiometer sensitivity.

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HIGH AVERAGE POWER ROTATOR

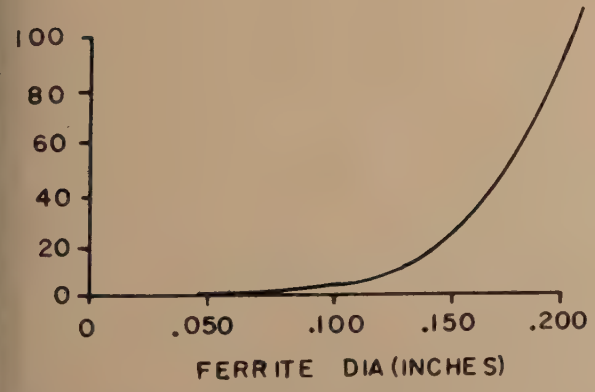
WALTER BEUST
EDWARD G. JOHNSON

RAYTHEON COMPANY
BEDFORD LABORATORIES
Bedford • Massachusetts

gh Average Power Rotator

With the development of the klystron amplifier, and her high power tubes, kilowatts of CW power up to X-band region have become available to the radar signer. These increased power levels accent the significance of losses occurring in any ferrite device operating in the high power line. The power lost in a device st be dissipated, and with 0.5 db insertion loss representing an eleven percent absorption of power, or 110 tts per kilowatt of transmitted power, low insertion s and power dissipating ability can become the limiting factors in component design.

The Faraday rotator section is a basic ferrite structure d can be used as a phase modulator, isolator, circulator waveguide switch. Without careful design, the rotator tion can suffer from low average power capability, n-linearity at power levels above 1 kw, and zero field ses when operating below saturation.



gure 1 — Saturation rotation for .625 dia. guide teflon and ferrite loaded.

Conventional Rotator Section

The conventional rotator section is shown in Figure 1. An axially located ferrite pencil is supported in a round guide by a dielectric sleeve. The saturation rotation of the ferrite is a function of the ferrite diameter and dielectric supporting material. A typical curve of saturation rotation/in. vs. ferrite diameter in a teflon guide section is shown in Figure 1.

Teflon is a very excellent microwave dielectric, but its thermal expansion and thermal conductivity coefficient are such that a unit with teflon dielectric could not handle more than 50 watts average power. Substitution of boron nitride as the dielectric material can increase the power handling ability of the device to above 200 watts average.

With a given dielectric support material, it is necessary for high power operation to maximize the ratio of surface area of the ferrite element to the power dissipated in the element which is defined as Q_D by P. Rizzi.[1]

The conventional rotator section can be optimized by reference to Figure 2.

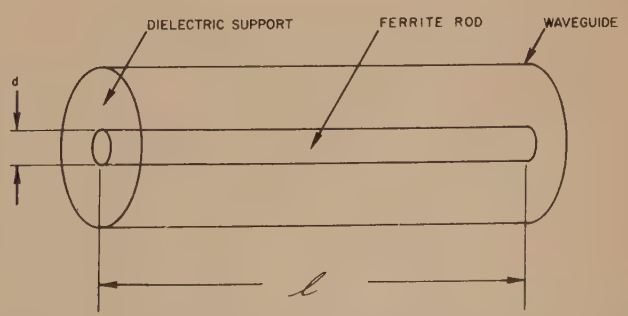


Figure 2 — Dielectric and ferrite rotator section.

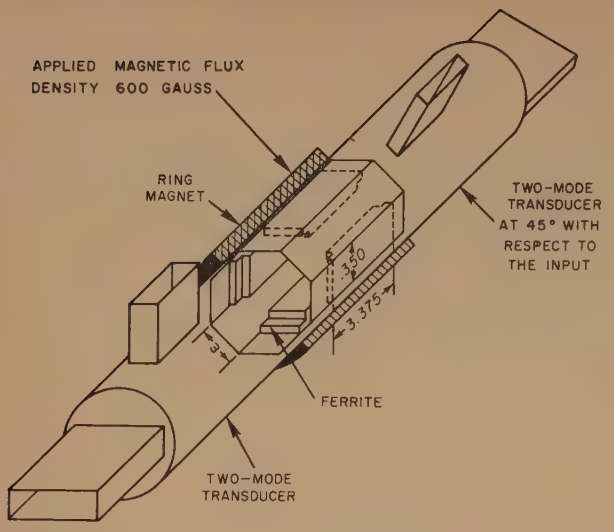


Figure 3 — High average power circulator.

(1) Dissipative Surface Area (DA) $= \pi dl$

(2) Loss (L) in ferrite $= K\pi d^2 l$
Substitution of (1), (2) into definition of Q_D yields

(3) $$Q_D = \frac{DA}{L} = \frac{\pi dl}{K\pi d^2 l}$$

where K is an assumed constant determined by the loss/unit volume.

$Q_D \propto 1/Kd$.

Thus, to maximize the dissipative area per loss, it is necessary to decrease the diameter of the ferrite rod. For a rotator section operating at saturation rotation, the longest possible ferrite should be used and the diameter adjusted for the required rotation. Referring to Figure 1, it is evident that if the length of a 45° rotator section is increased from one to two inches, the diameter of the rod decreases by 14 percent and Q_D thus increases by 14 percent.

The ferrite material used should have low loss along with high rotation per length. For operation below saturation, material with low zero field losses at the frequency of interest should be chosen. Q_D can be used as a qualitative comparison of different devices but is dependent on the ferrite material and the frequency of operation. A

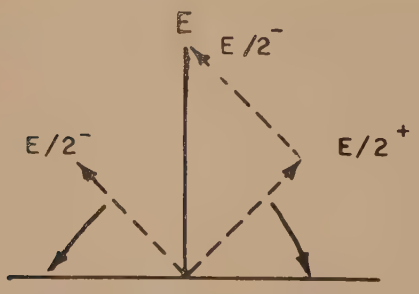


Figure 4 — Synthesizing a linear polarized field into two counter rotating circular polarized fields.

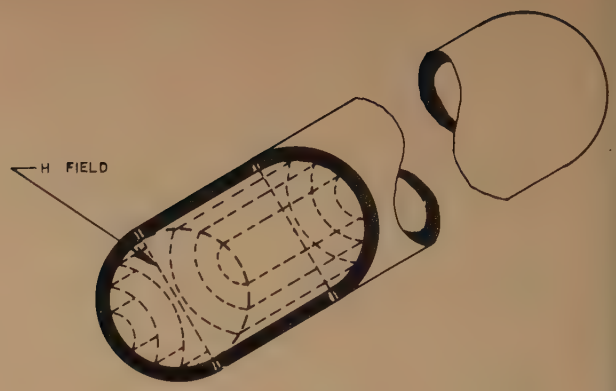


Figure 5 — Magnetic field distribution in a TE_{11} Mode.

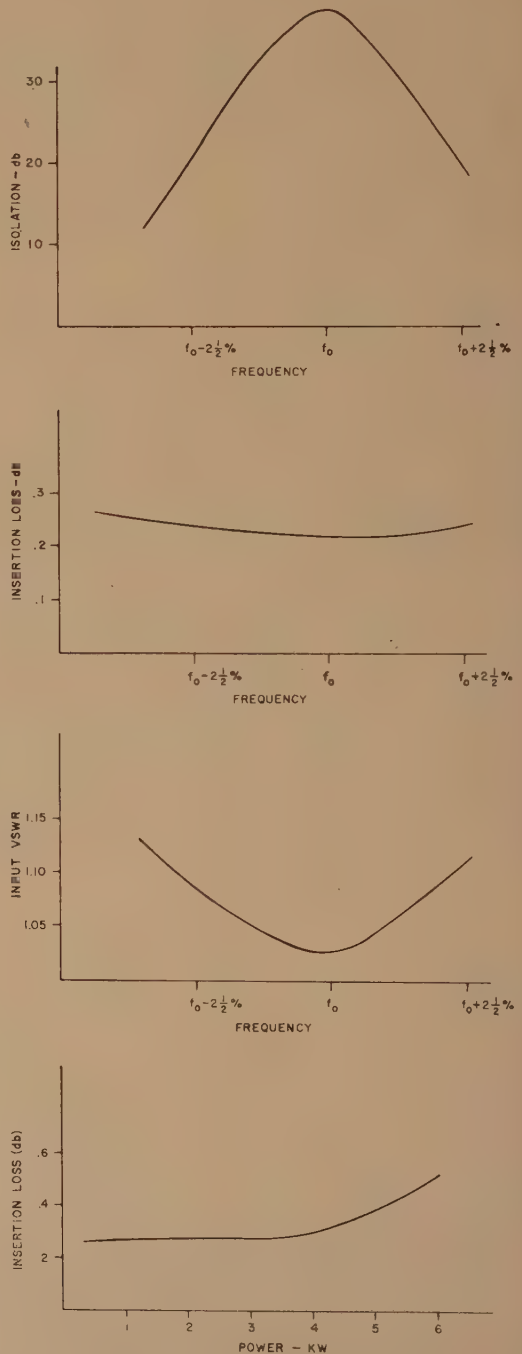


Figure 6 — Performance curves for circulator shown in Figure 3.

mprehensive article on the design of rotators is con-
ned in a previous issue of *the microwave journal.*[2]
Maximizing Q_D of a rotator also increases the power
vel at which non-linear loss becomes objectionable.[3] The
naller diameter ferrite decreases the strength of the r-f
ld in the ferrite for a given power level and thus in-
eases the power at which the non-linear losses become
gnificant compared to dielectric, mismatch and other
agnetic losses.

ab Rotator

To increase the power handling capabilities of a rotator
increasing the dissipative area and by placing the fer-
e in contact with the metal waveguide, a structure
own in Figure 3 was used. Faraday rotation in an axially
agnetized ferrite structure, Figure 2, depends on the
ference of the scalar propagation constants for two
unter rotating circular polarized fields transverse to the
rection of propagation. These counter rotating fields
n be synthesized from a linear polarized wave as shown
Figure 4. The sum of the two rotating fields is always
linearly polarized field. If the propagation constants
the two senses of circular polarization differ, one ro-
ing field will be sped up relative to the other, and the
sulting linear wave will be rotated through an angle αl.
The rotation per unit length (α) is related to the
opagation constants by

$$\alpha = \frac{\beta_- - \beta_+}{2}$$

here β_+ and β_- are respectively the left- and right-
nd circularly polarized waves propagation constants.
The existance in a TE_{11} wave of a transverse magnetic
ld near the waveguide wall from which two counter
ating fields can be synthesized is shown in Figure 5.
component of magnetic field in the direction of propa-
tion produces no rotation effect since the propagation
constant in this direction is independent of the sense of
circular polarization.

The four slab structure is an outgrowth of the hollow ferrite cylinder rotator section, and eliminates many of the electrical and mechanical problems encountered with the hollow cylinder.

Four slabs of width w are placed on alternate sides of the octagonal guide structure. The octagonal guide provides for automatic location of the ferrite slabs and also matches easily into the circular guide of the two mode transducers used in conjunction with the rotator section.

Design criterion for a rotator used in the circulator configuration, shown in Figure 3, was to keep the insertion loss at less than .3 db and the 20 db isolation bandwidth similar to that obtained in a dielectrically loaded ferrite rod rotator. A magnesium manganese ferrite, R151, manufactured by Raytheon, was used because of its low loss and high rotation sensitivity. With the electrical performance factors fixed, the dissipative area obtained was approximately five square inches — a factor of ten over the conventional rotator along with the advantage of mounting the ferrite directly to the waveguide.

Performance curves for the unit are shown in Figure 6. Up to 4 kw, the insertion loss is essentially that taken at low power with a slow increase to .5 db at 6 kw. No attempt to improve non-linear loss was initiated although improvements could undoubtedly be made by changing the geometry of the slabs.

---

1. P. Rizzi, "High Power Ferrite Circulators," IRE Transactions on Microwave Theory and Techniques, Vol. MTT-5, No. 4, October 1957.
2. P. Rizzi, "Ferrite Rotators," *the microwave journal,* Vol. I, No. 3, November/December 1958.
3. Sakiotis, Chait, Kales, "Non-linearity of Propagation in Ferrite Media," Proc. IRE, Vol. 43, p. 1010, August 1955.

NOMOGRAPH FOR DETERMINING WAVEGUIDE WAVELENGTH

B. R. HATCHER
Chu Associates • Littleton, Mass.

This nomograph is designed to yield the waveguide wavelength, λ_g, in terms of free space wavelengths, λ_o, when the ratio of the cutoff wavelength, λ_c, with respect to free space wavelength and the relative permittivity, $\bar{\epsilon} = \frac{\epsilon}{\epsilon_o}$, of the media filling the waveguide are known.

However, if any two of the three variables, $\frac{\lambda_g}{\lambda_o}, \frac{\lambda_c}{\lambda_o}$ and $\bar{\epsilon}$ are known, the third may be found from the nomograph.

The equation relating the variables is

$$\frac{\lambda_g}{\lambda_o} = \sqrt{\frac{1}{\bar{\epsilon} - \left(\frac{\lambda_o}{\lambda_c}\right)^2}} \qquad (1)$$

For example, suppose $\frac{\lambda_c}{\lambda_o} = 1.50$, $\bar{\epsilon} = 1$ a straight line thru these points on their respective scales yields $\frac{\lambda_g}{\lambda_o} = 1.34$ on that scale, which is the waveguide wavelength in terms of freespace wavelengths under those conditions.

Derivation

The equation for the waveguide wavelength in a waveguide filled with a dielectric having a relative permittivity $\bar{\epsilon} = \frac{\epsilon}{\epsilon_o}$ is

$$\lambda_g = \sqrt{\frac{\lambda_o}{\bar{\epsilon} - \left(\frac{\lambda_o}{\lambda_c}\right)^2}} \qquad (2)$$

dividing by λ_o, and taking the reciprocal of both sides of the equation

$$\frac{\lambda_o}{\lambda_g} = \sqrt{\bar{\epsilon} - \left(\frac{\lambda_o}{\lambda_c}\right)^2} \qquad (3)$$

squaring both sides

$$\left(\frac{\lambda_o}{\lambda_g}\right)^2 = \bar{\epsilon} - \left(\frac{\lambda_o}{\lambda_c}\right)^2 \qquad (4)$$

This can be rewritten

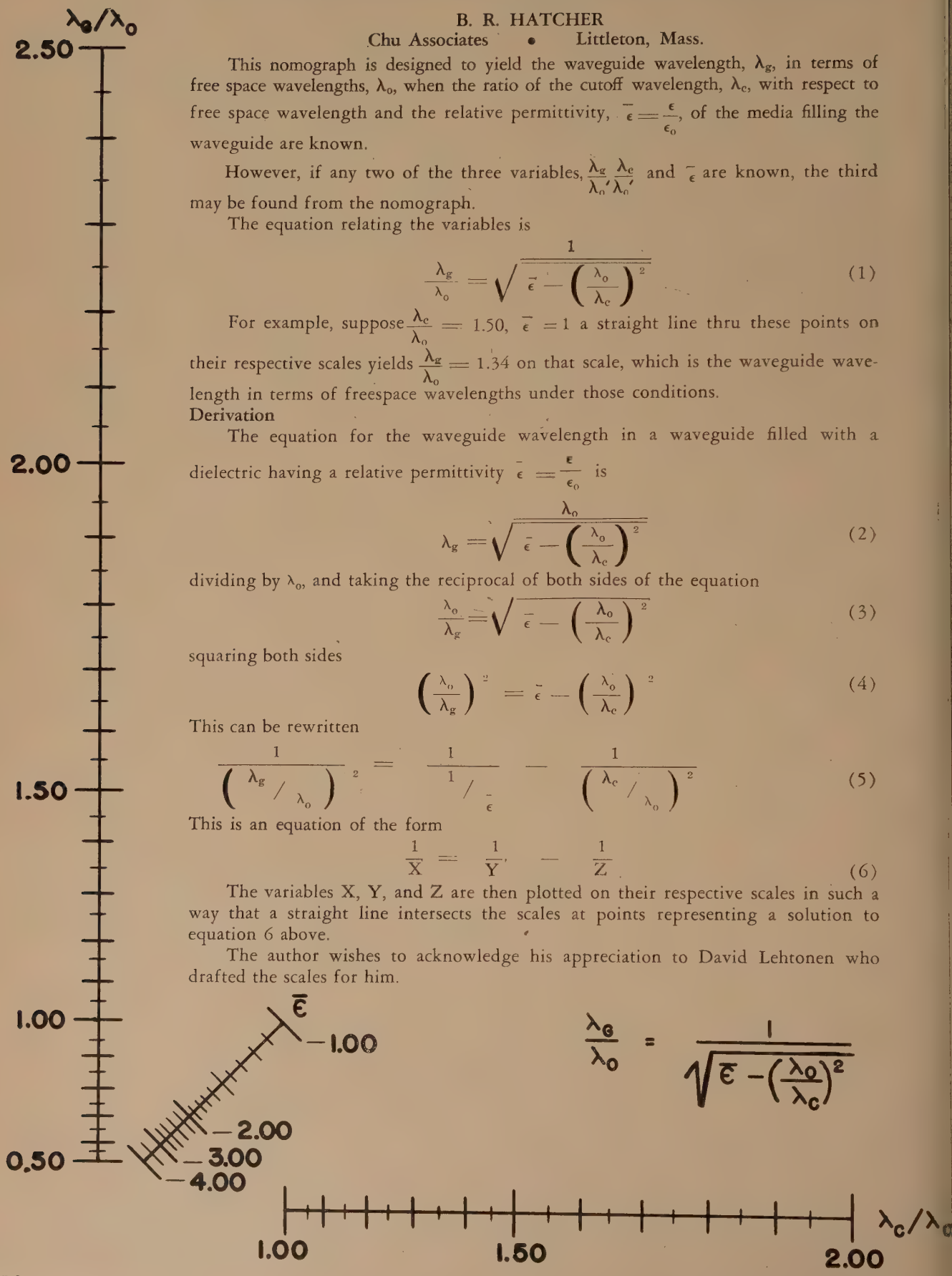
$$\frac{1}{\left(\lambda_g / \lambda_o\right)^2} = \frac{1}{1 / \bar{\epsilon}} - \frac{1}{\left(\lambda_c / \lambda_o\right)^2} \qquad (5)$$

This is an equation of the form

$$\frac{1}{X} = \frac{1}{Y} - \frac{1}{Z} \qquad (6)$$

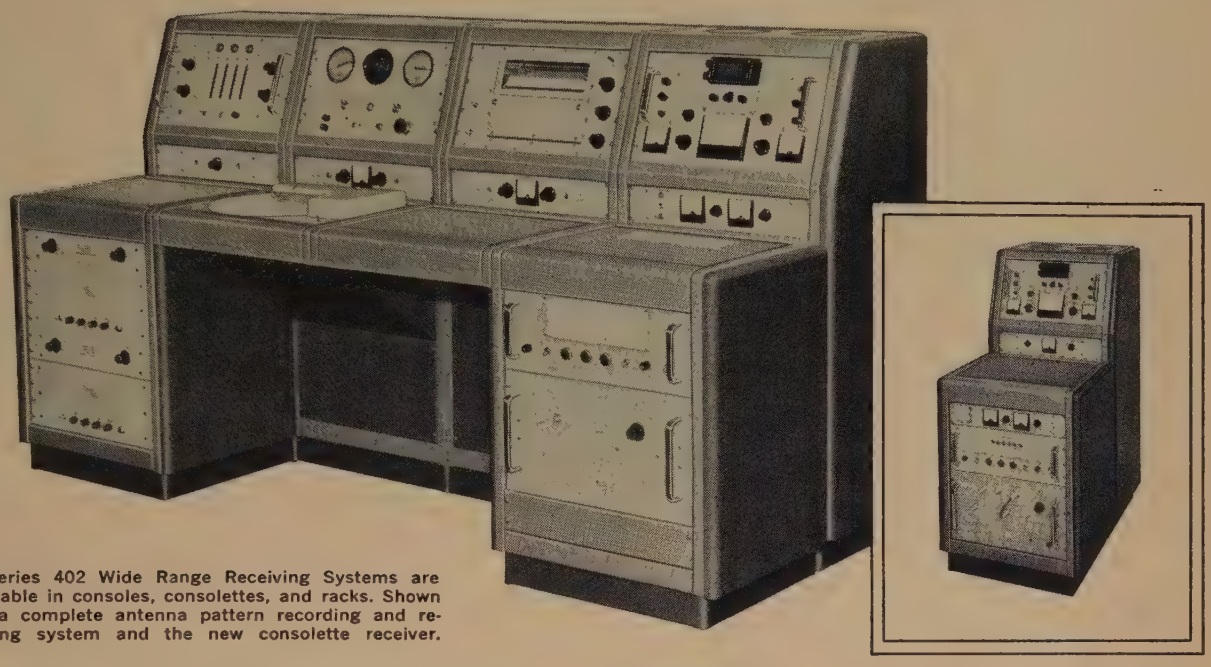
The variables X, Y, and Z are then plotted on their respective scales in such a way that a straight line intersects the scales at points representing a solution to equation 6 above.

The author wishes to acknowledge his appreciation to David Lehtonen who drafted the scales for him.



MAJORS and MINORS

...A Message to the Antenna Designer



● Series 402 Wide Range Receiving Systems are available in consoles, consolettes, and racks. Shown are a complete antenna pattern recording and receiving system and the new consolette receiver.

The crowded spectrum plus high power radar and communication systems critically compound the problems of the antenna design engineer.

More than ever, the complete pattern including **all** the major and minor lobes of every radiating element must be graphed for sound engineering evaluation.

S-A Receiver Gets the Whole Signal

Scientific-Atlanta Series 402 Wide Range Receiving Systems are specifically designed for antenna pattern measurements. Unique in design, these receivers combine maximum sensitivity and linearity from 30 mc to above 100 kmc. They are also useful as multipurpose laboratory instruments for microwave testing, monitoring, and measuring applications.

Only from S-A, 1 db Linearity over Full 60 db Dynamic Range

A recent development, S-A's P-4 modification adds 20 db to the normal 40 db dynamic range. The modification takes advantage of the gain vs AGC voltage characteristics of the Series 402. Existing receivers can be modified at the factory.

New Modification Z Broadens Use

Modification Z adds a precision IF attenuator and VTVM to the Series 402. Now RF and microwave signal level, gain, and isolation measurements can be made with fewer components and instruments. *For instance,* an X band 60 db attenuator can be calibrated to within ±0.5 db with a 1 mw signal source, a flap attenuator, a mixer, and an S-A Series 402Z Receiver. Antenna gain can be measured by direct comparison with a standard gain antenna. Signal levels can be compared against a reference standard.

Other Features

One coaxial cable from antenna to receiver eliminates costly lossy waveguides and rotary joints. Antenna can be located up to 75 feet away with negligible loss in sensitivity ☆ One receiving system covers 30 mc to above 100 kmc without plug-ins ☆ Reception of cw signals from simple sources eliminates need for precise modulation ☆ High sensitivity means low source power and long ranges ☆ High selectivity reduces interference and cross talk between adjacent test ranges ☆ Positive AFC action over full dynamic range provides pattern recording in deep nulls.

PRICES

Series 402, 2 to above 100 kmc	$7500
Series 402A, 2 to above 100 kmc with AGC	8000
Series 402B, 30 mc to above 100 kmc	8500
Series 402C, 30 mc to above 100 kmc with AGC	9000
Modification P-4	500
Modification Z	1000

NEW DATA FOLDER READY

For complete information ask for our new data folder from your nearby S-A engineering representative or write directly to Dept. 69

SCIENTIFIC-ATLANTA, INC.

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ATLANTA 9, GEORGIA
PHONE: TRinity 5-7291

3

Industry News

(*Continued from page 36*)

headquarters building. Construction is scheduled to begin this summer, with completion scheduled for early 1961.

The Applied Research Laboratory, presently located within the Waltham Laboratories, is responsible for the investigation and creation of new electronic systems techniques to meet the requirements of government and industry. It provides consulting services to the nine other laboratories and six plants within Sylvania Electronic Systems and also makes these services available to other GT&E organizations.

Approximately 150 persons, including 90 technical personnel, will be employed within the new Applied Research Laboratory building, engaged in such advanced areas as the dynamics of information processing, radio physics, communications biophysics, and data encoding. Of the technical personnel, approximately one-third have PhD degrees and the majority of the remainder have master's degrees in various scientific areas.

Sylvania Electronic Systems is engaged in research, development and manufacturing activities in advanced electronic fields. These include data processing systems; communication, navigation and intelligence systems; detection, tracking and defensive missile systems; electronic warfare systems; related equipments, components and support systems, and related study programs.

MICROWAVE ASSOCIATES ADDS STAFF MEMBERS

Microwave Associates, Inc., announces the appointment of Mr. Herbert N. Cox and Mr. Robert Terry to its staff.

Terry Cox

Mr. Cox as a member of the Sales Department will handle sales engineering for the Components Division and will be involved with all waveguide components, microwave test equipment, and custom-engineered components and sub-systems assemblies. Prior to joining Microwave Associates, Mr. Cox was with Hughes Aircraft-Ground Systems Division, Fullerton, California for three years and participated in the design of microwave components and systems. He was also with RCA-Defense Electronics Products Division, Los Angeles before joining Hughes. He received his B.S. in Electrical Engineering from the University of California in 1954.

Mr. Terry, as a Senior Engineer with Microwave Associates' Components Division will specialize in the design and development of complex microwave assemblies and sub-systems. Before joining Microwave Associates, Mr. Terry was Supervisor of the Microwave Electronics Section at Airtron, Inc., New Jersey. He was active in the design and development of microwave components and associated electronic sub-systems. His background includes experience as a Test Engineer with Bendix Radio in Maryland. Mr. Terry is a member of the Institute of Radio Engineers and of the Professional Group on Microwave Theory and Techniques.

Both men will have their offices in Microwave Associates' new Components Division building which will be occupied during the first week of May.

—*mwj*—

PONVERT V-P AT GENERAL COMMUNICATION CO.

General Communication Company, Boston, Mass., announces the appointment of Mr. Edwin K. Ponvert to the position of vice president. Mr. Ponvert, a graduate of the United States Naval Academy, was previously associated with the Electronics Division of Benrus Watch Company as sales manager and with Greer Hydraulics Inc. as assistant to the president.

—*mwj*—

(*Continued on page 87*)

IF YOU DEPEND ON FERRITES ...YOU DEPEND ON IRVAN

from microwave to recording head frequencies, Irvan has a national reputation for superior performance. Irvan has the most complete and up-to-date facilities in the country for ultrasonic, surface, centerless, OD and ID grinding and has on hand over 30 grades of ferrite material for "yesterday" delivery on your ferrite orders.

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MICROWAVE ENGINEERS

APPLIED ELECTRONICS DEPT.

Airborne Instruments Laboratory has several desirable positions available for competent, inventive microwave engineers, preferably with an advanced degree and at least 3 to 5 years experience.

Successful applicant will perform and supervise advanced development work on

- Parametric Amplifiers
- Solid-State Masers
- Ferrite Devices
- Frequency Compression Networks
- Microwave Radiometers

Although specific experience in one or more of these areas is desirable, those with an applicable microwave or applied physics background will also be considered.

SALARY OPEN

Send complete resume to Mr. Arthur Doherty

AIRBORNE INSTRUMENTS LABORATORY
A Division of Cutler-Hammer, Inc.
DEER PARK, LONG ISLAND

slotted line performance...?

—here are design parameters uniquely defined

Note how comprehensively D-B parameters cover all requirements of a standing wave detector.

D-B units are designed for unprecedented accuracy, repeatability, and operator convenience. They're built with high-precision parts, under close quality control. Attractively styled and fully guaranteed, they have achieved a tremendous acceptance by the industry.

Interchangeability with precision. Any D-B unit will handle adjacent frequency bands by using a different size waveguide block and probe. You can make the change in 30 seconds, with no loss whatever in alignment accuracy.

Complete range of sizes—10 models cover from 5.85 KMC to 140 KMC—or you can purchase interchangeable blocks and probes to extend the range of any model, at a saving.

Uniformity of waveguide surfaces. D-B provides a high internal surface uniformity by precision machining its millimeter waveguides, and using carefully selected precision waveguide for lower-frequency units. This construction insures a uniform path for measured waves, thus minimizing residual VSWR.

Slot excitation is negligible, resulting in minimum RF leakage—another reason why residual VSWR is very low.

Probe impedance is properly matched to the waveguide. Uniform probe penetration is provided by a fast, convenient slope adjustment, made in a few minutes.

Adequate probe travel ($\geq 1\frac{1}{2}\ \lambda_g$) available at all frequencies. Operator can read at least 3 maxima and 3 minima of VSWR.

Efficient mechanical translation. D-B mechanism functions with exceptional smoothness, giving the unit a definite instrument "feel." Five point kinematic carriage suspension insures excellent linearity of probe motion.

Vernier readout on knob periphery permits reading of probe travel to .01mm without mounting of costly accessories.

Continuously variable drive ratio changes carriage travel from "vernier" to "fast"—a time saver during rapid measurements.

Direct phase readout. Phase shift may be measured accurately on the calibrated knob, which reads percentage of 180° directly.

For complete data, see your D-B Catalogue, or request folder DB-825.

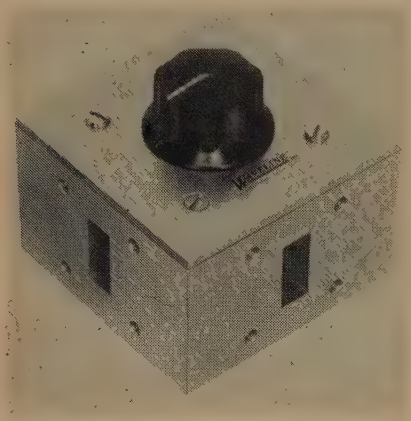
Interchangeable waveguide blocks. Each realigns perfectly to probe travel in a few seconds.

DE MORNAY BONARDI®

780 SOUTH ARROYO PARKWAY • PASADENA, CALIFORNIA

New Products

X-BAND WAVEGUIDE SWITCH



Waveline, Inc., Caldwell, N.J., announces its new Model No. 678-E waveguide switch. This unit is a manually operated four-port waveguide switch for use over the full range of 8.2 to 12.4 Kmc. This precision X-band switch has been designed for laboratory use or for systems application to make alternate connections between two waveguide inputs and two waveguide outputs.

By virtue of precision manufacturing methods and high quality assembly techniques, the switch is able to perform with excellent electrical characteristics. A unique feature of the switch is a low VSWR for broad band operation. The specific characteristics over the frequency range of 8.2 to 12.4 Kmc are: VSWR of less than 1.05, crosstalk or isolation between ports is greater than 45 db. Attenuation through any channel of the switch is negligible and power handling capacity is approximately the same as the waveguide itself.

The basic construction of the switch is of aluminum alloy with an iridite finish painted instrument grey enamel. Physical size is approximately 3 x 3 x 3 inches and flanges are equivalent to UG-135/U with #8-32 tapped mounting holes. The switch is normally supplied with rotation in the narrow wall plane (circular bend of the rotor in the "E" plane) and is manually operated by means of a knob. An "H" plane version of this switch is also available as Waveline Model No. 678-H.

Circle Reader Service Card 101

—mwj—

PHILCO ANNOUNCES IMPROVED MICROWAVE MIXER DIODES

The Lansdale Division of Philco Corporation, Philadelphia, Pa., has announced the availability of the new 1N78D silicon point-contact diodes in production quantities.

Dr. C. H. Sutcliffe, head of the Division's Special Components Department, revealed that the 1N78D microwave diodes bring low-noise mixer performance to the Philco family of crystals specified for 16,000 mc first detector operation.

Featuring a maximum conversion loss of 5.7 db and overall noise figures of 7.5 db, improvements in receiver sensitivity are possible.

Like the new crystal's forerunners in the 1N78D series, the 1N78D is hermetically sealed and is specified for operation up to 150°C. The series also features IF impedance range tightened to 400-565 ohms; RF impedance (VSWR) reduced to 1.5.

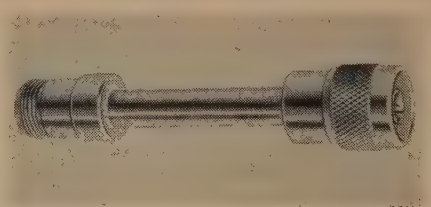
The new 1N78D is unilaterally interchangeable with the 1N78C, 1N78B, 1N78A and 1N78 and is available in matched pairs for balanced mixer operations.

Specifically designed to meet military environmental and electrical requirements for shock, vibration, torque and strain, the 1N78 series mixer diodes have received widespread usage in conventional radar circuitry among their applications where low noise operation at 16,000 mc is required.

Circle Reader Service Card 102

—mwj—

COMPLETE NEW LINE OF COAXIAL FILTERS



Microlab, Livingston, N.J., has just announced a complete new line of low pass and high pass filters. These filters are available for frequencies from 100 to 10,000 mc and in high power or miniaturized versions as well as standard sizes.

The low pass filters are carried in stock with cut-off frequencies from 100 to 10,000 mc. They are available in the standard model with a power rating of 10 to 50 watts, in the high power model with a 500 watt rating or as miniaturized units for least possible overall length. The high pass filters are stocked either in standard or miniaturized models.

All of the filters are supplied with one male and female connector in either the N, BNC, TNC, C or HN series. Other combinations can also be supplied. They are ruggedly constructed to meet the environmental conditions of MIL-E-5272B and other similar specifications.

One hundred and ninety-five different filters are available for immediate delivery from stock and are priced from $30 to $65 depending upon the type and connectors. The units are described completely in the newly released Catalog 9C available from the manufacturer.

Circle Reader Service Card 103

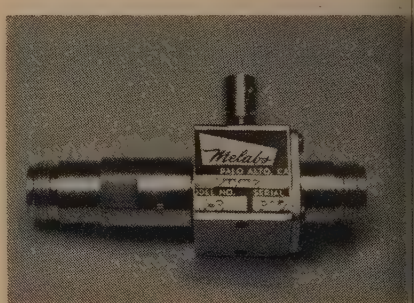
ALL-ELECTRONIC TARGET SIMULATOR

Remanco, Inc., Los Angeles, Ca designers and manufacturers of radar te equipment and other electronic system announce the marketing of a new al electronic simulator for realistic ope ation of a radar system. Operating ov a wide dynamic range, the company sa that this new all-electronic RTS-101 seri is one of the most efficient simulation sy tems now available . . . capable of simula ing everything from pedestrian traffic missile tracking. When the radar antenn is directed at the horn of the RTS, "ain ing at a target," it provides a rapi complete check-out of the radar syste For increased operator efficiency, th microwave target pulse is AFC'd to th radar's frequency. One-knob turning e ables frequency lock to be obtaine rapidly, without ambiguity. This un may be connected to IF and video circui permitting logical or step-wise troubl shooting. The standard, off-the-shelf RT 101 is an X-band device, but can b modified for other bands. Angular trac ing may also be checked.

Circle Reader Service Card 104

—mwj—

BROADBAND COAXIAL MIXER



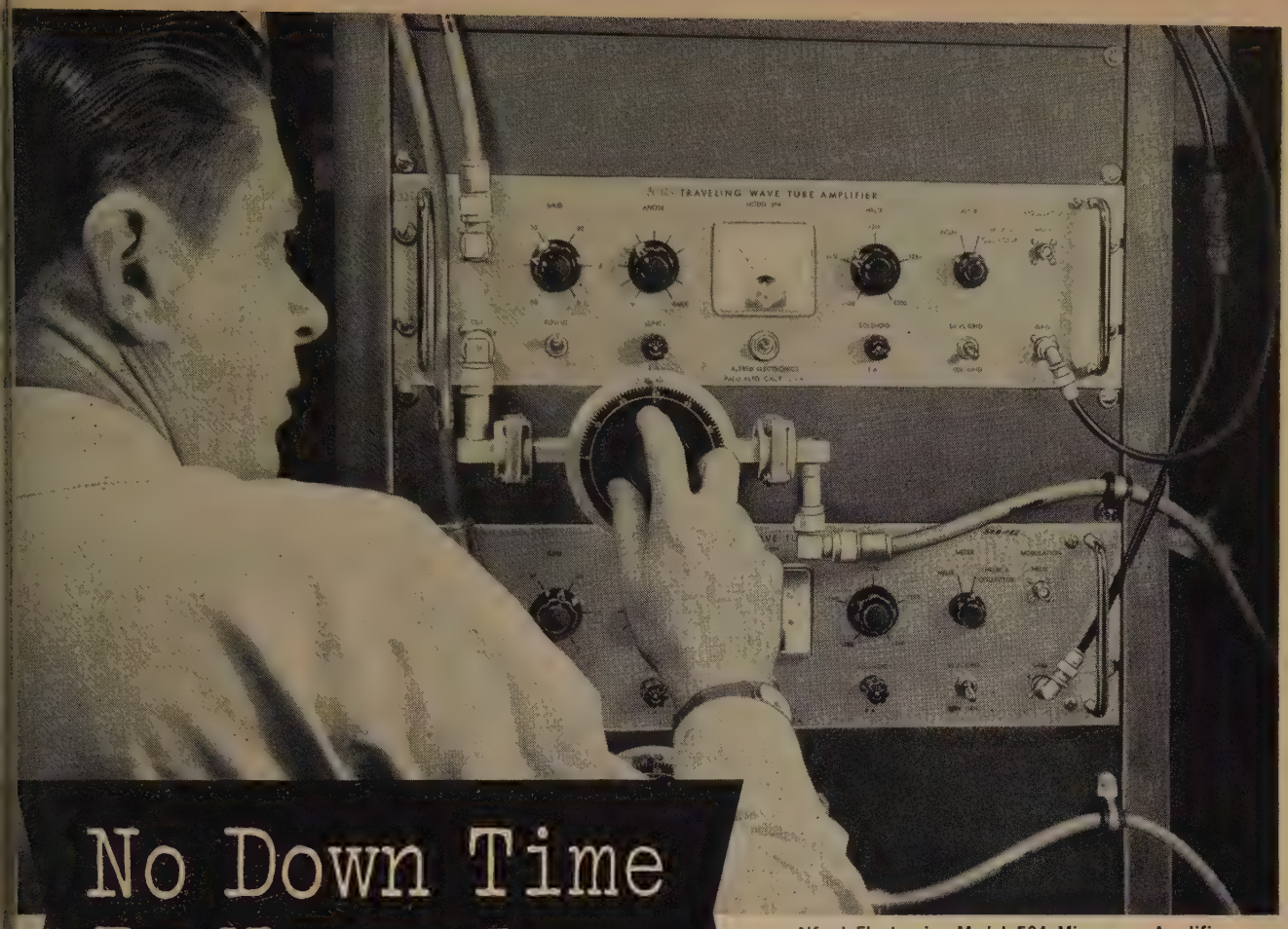
Melabs, Stanford Industrial Park, Pa Alto, Cal., has developed a broa band untuned coaxial mixer mount, Mod M-3 providing conversion losses of b tween 6 and 10 db from 0.5 to 11 km The mixer uses double ended crysta of 1N415 or 1N416 series. L.O. pow requirements have been minimized in th design so that sufficient bias is produce by 1-2 mw to operate the crystals at the correct level.

DC isolation is provided on one si of the crystal by a series capacitato A dc return is necessary in the sign source for proper operation of the mixe The signal and L.O. inputs are type female connectors and the IF output is type BNC female connector.

The M-3 has also been found to very useful as a varactor mount for par metric amplifiers and limiters.

Circle Reader Service Card 105

(*Continued on page 65*)



No Down Time Is Normal...

Alfred Electronics Model 504 Microwave Amplifiers, in use at Hughes Aircraft Co., Culver City, California

with ALFRED Microwave Amplifiers

hese Alfred TWT microwave amplifiers have seen con-uous service at Hughes for over 9 months. There has en practically no down time even for replacement of WT tubes. Used in the RF portion of a missile testing stem, the Alfred units provide high gain, wide band, t response and low spurious modulation from 8 to 12.4 kmc. Hughes engineers praise the functional layout of the Model 504, its simple operation and reliable performance.

In short, Hughes finds the Alfred 504 Microwave Amplifiers good, sound, straightforward reliable instruments. We think you will too.

EY SPECIFICATIONS—ALFRED MICROWAVE AMPLIFIERS

	Model	Frequency Range kmc	Gain db (min)	Power Output (min)	Price
General Purpose Amplifiers for AM, Pulse and hase Modulation	505	1 to 2	30 db	10 mw	$1,550
	501	2 to 4			$1,390
	503	4 to 8			$1,490
	504	8 to 12.4			$1,490
	549	10.5 to 16			$3,550
Medium Power Amplifiers	5-6752	1 to 2	30 db	1 w	$2,290
	512	2 to 4	30 db	1 w Pulsed	$1,850
			20 db	100 mw CW	
	502	2 to 4	30 db	1 w	$1,390
	5-6868	2 to 4	30 db	10 w	$2,850
	506	4 to 8 / 4.5 to 7.5	27 db	.5 w / 1 w	$2,290
	5-542	4 to 8	25 db	1 w	$3,190
	510	8 to 12.4	20 db	100 mw	$2,150
	509	8.2 to 11	27 db	.5 w	$3,150
	5-6996	8 to 9.6	30 db	10 w	$3,590
High Power Amplifiers	5-6826	2 to 4	30 db	1 kw pk	$4,850
Low and Medium Noise Figure Amplifiers	Amplifiers with low and medium noise figures are available either as packaged units or unitized for remote operation of TW tube and solenoid. Standard units provide coverage from .5 to 12.4 kmc with noise figures from 7 db up.				

MANY MODELS TO CHOOSE FROM

The 504 is just one model from the industry's most complete line of microwave amplifiers. For technical details and a demonstration arranged at your convenience, contact your nearby Alfred representative or write direct. Please address . . . Dept. 69.

ALFRED ELECTRONICS

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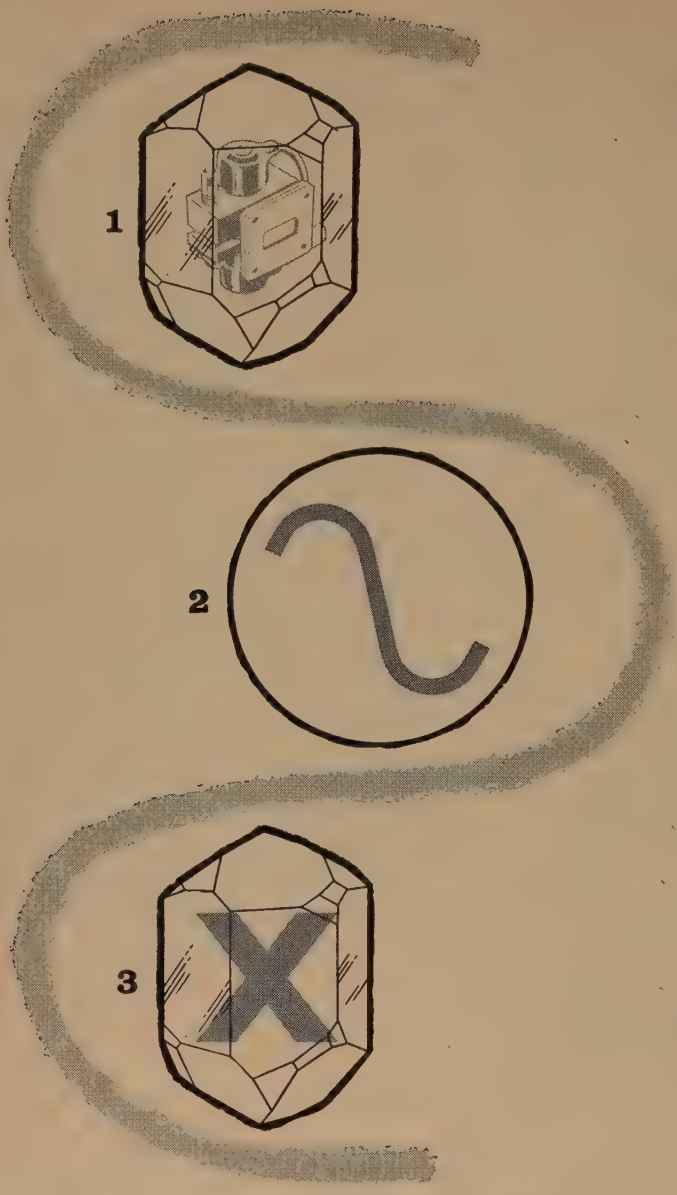


3 approaches to MICROWAVE STABILITY

3 different "state-of-the-art" approaches for achieving microwave frequency stability are utilized in the LFE Oscillators described below. Each of these instruments exemplifies LFE's leadership in this specialized field. Separate data bulletins are available on each series. Write for a full set today.

	1 Crystal-Locked Klystron Approach	2 Dual-Mode Reference Cavity Approach	3 Crystal Multiplier Approach
LFE MODELS	Series 820-XLK Crystal-Locked Klystron Source	Series 814 Ultra-Stable Microwave Oscillator	Model 5010 S-Band Exciter
FREQUENCY RANGE	S-band to K-band fixed frequency	27 tunable models covering 2.5 mc —27Kmc	S-band fixed frequency
POWER	Approx. full klystron power	Up to 500 mw @ X-band or 1.5 w @ C-band	125 mw
SHORT-TERM STABILITY	1 part in 10^8	5 parts in 10^8	1.2 cps (incidental FM)
LONG-TERM STABILITY	1 part in 10^6 (24-hour period) Generally independent of environmental conditions	1 part in 10^6	Less than 100 kc drift over 25-hr. period

LFE

INSTRUMENT DIVISION

LABORATORY FOR ELECTRONICS, INC.

714 BEACON STREET • BOSTON 15, MASSACHUSETTS

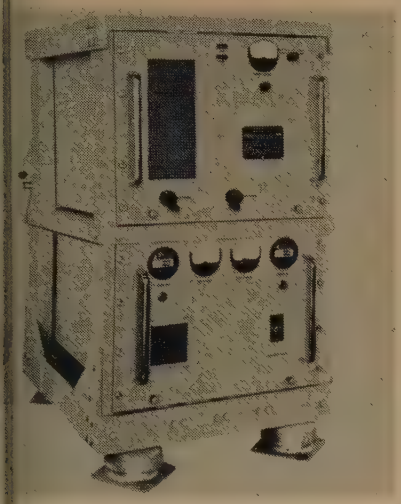
WESTERN REGIONAL OFFICE, 211 South Beverly Drive, Beverly Hills, California.

Circle Reader Service Card 39

w Products

(*Continued from page 62*)

1 KW RF AMPLIFIER 225 to 400 Mc.



he Manson Model RD-210, manu-ured by Manson Laboratories, Inc., nford, Conn., is a 1 KW RF amplifier rated class "B" linear. Designed as inal stage amplifier for a UHF trans-er, it is continuously tunable from to 400 Mc. with a carrier operating ither F-1 or A-3 mode. Completely contained, the RD-210 incorporates pactness, ruggedness and simplicity peration into one high powered pack-

uning is accomplished by a simple knob adjustment working in conjunc- with a positive gear train that adjusts the grid and plate tuning circuits ltaneously. This method insures ease lignment with a minimum of error. plification is obtained with two air- ed tetrodes, thus permitting a reduc- in physical size and weight. The nt-in power supplies also contribute ompactness by utilizing silicon diodes lace of conventional tubes.

he Model RD-210 provides complete itoring of all pertinent supply volt- and currents along with forward reflected output power. Provisions metering VSWR and for frequency ment are also included. Completely ected, the amplifier contains overload bias-failure relays plus air-cooling re alarms.

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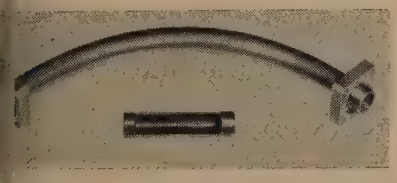
— m w j —

NIQUE CIRCULAR WAVEGUIDE BENDS FOR THE MILLIMETER-WAVE V-BAND, 60-75 KMC.



mple and complex bends in millime- and circular waveguide are now being fabricated, as the result of a newly developed method of waveguide construction. The unique waveguide bends, available from TRG, Inc., Antenna and Microwave Department, Somerville, Mass., are made by first corrugating the inside of lengths of straight copper waveguide and then bending them to the desired shape.

The new method of construction was developed to make use of the TE_{01} mode in circular waveguide, preferred because of its circular symmetry and low loss. The corrugations overcome the problem of deviations from straightness and the resultant mode conversion to the degenerate TE_{11} mode. In addition, the new method allows complicated bends to be made with little or no machining.

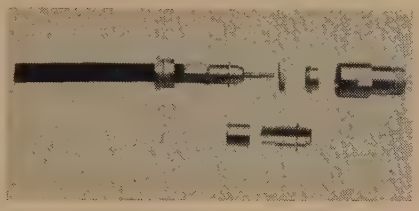
A typical 90° bend made with the new method, Model V-BMM 1, has a three-inch inside radius. The waveguide inside diameter is .353 inches. The loss in this particular section is less than 0.2 db. Bends at angles other than 90° or simultaneous bends in two dimensions are also available.

An illustrated catalogue with complete specifications on waveguide bends and other new millimeter-wave components is available from the manufacturer.

Circle Reader Service Card 107

— m w j —

NEW K-GRIP ATTACHES RF CONNECTORS TO COAXIAL CABLE

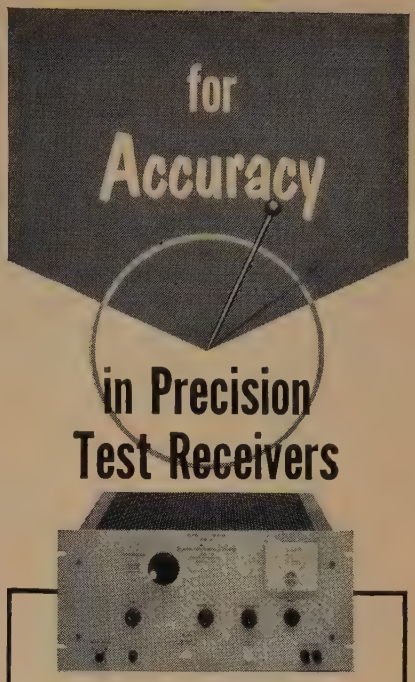


A new method for attaching RF connectors to coaxial cable is now manufactured and available from Kings Electronics Company, Inc., Tuckahoe, N.Y., under license from Douglas Aircraft Corporation. This method embodies the use of Kings' K-Grip and offers many features not to be found in conventional connectors.

According to the manufacturer, the new K-Grip connectors provide the following advantages:

1. Connector parts can be readily removed for inspection or replacement in the field without disturbing or impairing the electrical characteristics of the cable assembly. 2. When K-Grip connectors are used greater uniformity of performance is achieved from unit-to-unit. 3. Both the cable braid and the dielectric are firmly held by the K-Grip resulting in superior strength of the connection. K-Grip eliminates the need for a captive contact. 4. K-Grips for Type RG-8/U cable can be used with over 50 standard RF

(*Continued on page 67*)



THE AIL TYPE 132

This high precision instrument combines a high gain, low noise figure, intermediate frequency receiver with a secondary standard of attenuation to deliver extremely accurate measurements in a variety of applications:

- Convenient and accurate method for the measurement of **NOISE FIGURE.**
- Ideally suited to high accuracy, quick laboratory **calibration of rf attenuators** at all frequencies.
- Rapid and accurate in measurement of the **selectivity characteristics** of rf filters, preselectors and similar devices.
- Valuable for measurement of **coupling factors** and directivities.

The Type 132 is designed to operate from the i-f output of a wide variety of standard microwave mixers. In combination with these and a suitable local oscillator it becomes a sensitive detector of microwave energy.

Write for descriptive literature.

AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, NEW YORK
A DIVISION OF CUTLER-HAMMER, INC.

Circle Reader Service Card 40

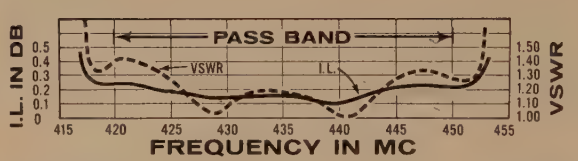
MC RF Filters

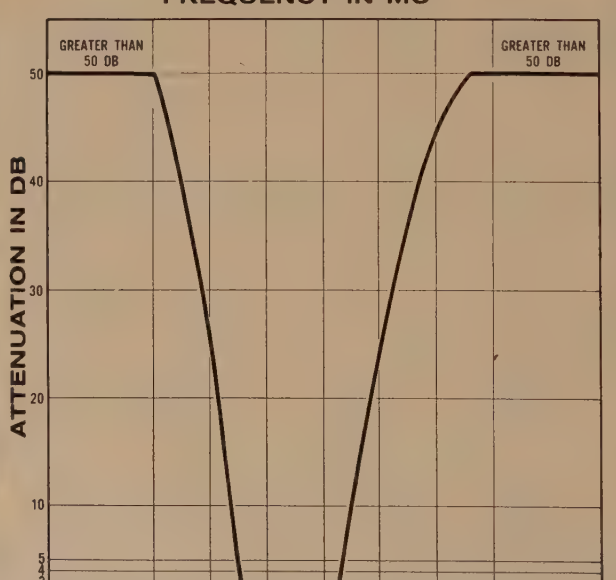
HIGH POWER CAPACITY BAND-PASS FILTER

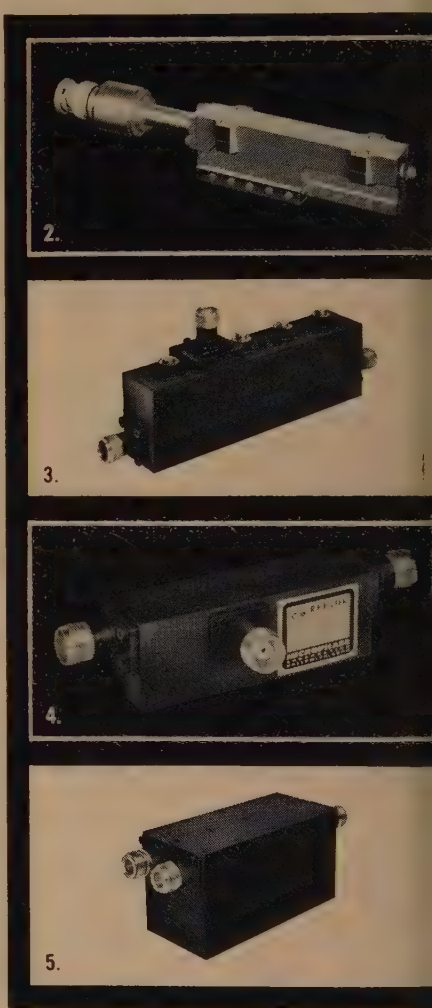
2 MEGAWATTS PEAK
(AT 15 PSIG)

420-MC to 450-MC BAND

RG 154/U TRANSMISSION LINE INPUT and OUTPUT







2. Subminiature Band-pass Filter Crystal-Mou Assembly. Unit weighs 3 ounces complete, h 50 DBM tangential sensitivity in the 2.6-to-3 KMC region.
3. Miniature L-Band Preselector-Mixer Assemb for 30- or 60-mc IF operation. Efficient min ture unit for airborne application.
4. L-Band Diplexer with 1.0-db maximum Inse tion Loss over wide bands, with minimum Isol tion of 60 db.
5. UHF Telemeter Diplexer with 1.0-db maximu Insertion Loss; 1.31:1 maximum VSWR ov octave passbands. Isolation is 40 db minimu

MICROPHASE CORPORATION

Box 1166W Greenwich Conn. NO 1-6200 WE 9-1998 Teletype: GREENWICH CONN. 7

Circle Reader Service Card 41

ew Products

(*Continued from page 65*)

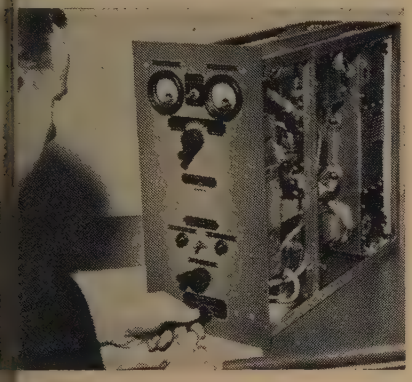
connectors and are also available for other standard cable sizes. 5. Assembly is accomplished by means of a readily available, inexpensive Thomas & Betts tool. 6. K-Grips reduce time of attaching of connector to cable. Highly skilled personnel are not required. 7. Soldering may be eliminated on connectors which have brass center contacts because the center contact may be crimped to the cable's center conductor by the same tool. 8. Kings' K-Grip does not obsolete present inventories of connectors.

Descriptive literature on Kings' K-ips is available from the manufacturer.

Circle Reader Service Card 108

— m w j —

MICROWAVE ASSEMBLY FOR TRANSPONDER CHECK-OUT



Transco Products, Inc., Los Angeles, ., recently delivered a number of crowave Assemblies to calibrate the crowave transponder of the Azusa acking System. The Transponder demines the tracking range of the entire tem. Transco designed and manufaced the microwave components to fit new reduced package size.

The small 8" x 18" x 21" Microwave it has a variable output range from 10 DBM to —100 DBM; provides a dout scale which indicates transponder tput directly in DBM in lieu of conrsion chart type scale; allows readout nters to be interchanged without calibran by simply adjusting two trim potenmeters; is designed so that all parts electrically and mechanically interangeable; can be mass produced, and thstands environmental testing in acrdance with applicable military specifiion.

Transco states the following components the Assembly are available for delivery d integration into other systems; crystal xer holder; matching network; filter; brid; crossguide coupler; precision veguide, level set and variable coaxial enuators.

Circle Reader Service Card 109

— m w j —

NEW PRD STANDING WAVE AMPLIFIER

The new portable PRD 277-B Standing Wave Amplifier, manufactured by Polytechnic Research & Development Co., Inc., Brooklyn, N.Y., features low inherent noise (0.007μv) and attenuation in 5 db steps. The PRD 277-B also provides an attenuation range of 85 db; four regular VSWR scales plus one expanded; meter scales automatically normalized, and a large 5-3/4 inch meter with 1% linearity.

Weak signals which once were undetected by conventional instruments can now be measured with the PRD 277-B due to its low inherent noise level. This instrument is a high gain audio amplifier designed primarily for use with slotted sections in making standing wave measurements. DB scales facilitate the use of the amplifier, in conjunction with crystal or bolometer detectors, for relative power and attenuation measurements.

Additional specifications of the PRD 277-B are: front panel adjustments of gain (15 db range) and bandwidth (4 to 40 cps); front panel meter monitors bias control, and center frequency (1000 cps) of the amplifier is adjustable over a 2% range.

The unit is 7-3/4" wide, 10-1/2" high, 11" deep, and weighs 14 lbs.

Circle Reader Service Card 110

— m w j —

G.E. ADDS NEW TWT

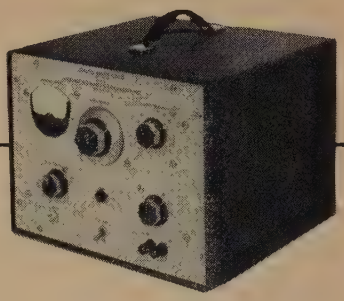
A "ruggedized" broadband amplifier for use in the 8000-to-12,000 megacycle frequency range is the latest addition to General Electric Power Tube Department's line of low-noise traveling-wave tubes.

Designated Z-5259, the new tube is designed for input service in radar receivers but has a wide range of other possible uses.

These include applications in radio astronomy, radiometry, countermeasures and microwave relay systems. The tube also can be used as a limiter and automatic gain control tube or as a microwave mixer and frequency divider.

(*Continued on page 68*)

Short Term Frequency Stability measured with High Accuracy



THE AIL TYPE 392B

Frequency Stability Tester for Checking Drift, Jitter, Jitter rate

- *Checks L- and S- band oscillator performance*
- *Responds to input levels as low as —45 dbm*
- *Checks frequency stability to 1 part in 10^9.*

It is particularly useful for the measurement of MTI Stalo stability during the short time interval when Stalo drift may cause erroneous target information. It operates in the approximate bands of 1120 to 1700 mc and 2600 to 3200 mc. The AIL type 392B provides rapid design and production checks. Compact, lightweight and portable it is ideal for field testing.

Write for descriptive literature.

AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, NEW YORK
A DIVISION OF CUTLER-HAMMER, INC.

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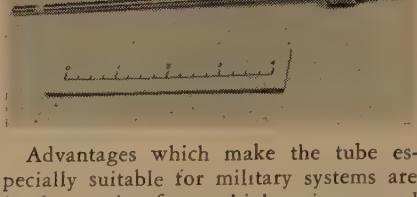
ANTENNAS
by
Ainslie
CORPORATION

NOW — available from Ainslie Corporation, a new remote control positioning pedestal capable of handling our antennas up to 18 feet in diameter in frequencies from 100 to 10,000 mc. Modifications available for a variety of tracking applications. Whatever your antenna or reflector requirements may be, contact us at our new facilities.

Ainslie
CORPORATION

531 Pond Street
South Braintree 85, Massachusetts
Circle Reader Service Card 43

(*Continued from page 67*)



Advantages which make the tube especially suitable for military systems are its low noise figure, high gain, rugged construction, broad bandwidth and freedom from mechanical tuning.

Within the 8000 to 12,000 mc frequency range, the noise figure is less than 10 db, gain is at least 25 db and power output across the entire band is 5 milliwatts.

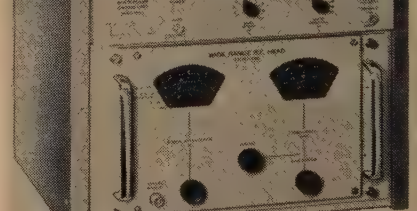
Of metal-ceramic construction, the tube has been tested successfully to withstand shock at 50 g's and vibration at 5 g's.

It is supplied as a complete package including permanent focusing magnets, connectors and housing. The whole assembly weighs 11.5 pounds. It has an over-all length of 9.25 inches with a width of 4.6 inches and height of 3 inches. It may be mounted in any position. The Z-5259 is available in production quantities.

Circle Reader Service Card 111

—mwj—

NEW MICROWAVE SPECTRUM ANALYZER



A new Microwave Spectrum Analyzer, Model SA-40 with interchangeable RF Heads for frequencies from 2,000 to 38,600 mcs, has been released by Applied Dynamics Corporation, Waltham, Mass. Its 40 mc amplifier has three available bandwidths, 5 kc, 25 kc and 200 kc, under selector knob control. Also under push button control are scope calibration and image check.

This new model provides improved sweep circuity for greater stability and includes provision for a Multi-pulse Gating Unit, available as an accessory, for analysis of the individual pulses in an RF multi-pulse train. The Gating Unit circuity follows the microwave RF Head, gating the signal to the IF amplifier. Aluminum construction has been used to reduce weight and make the SA-40 Microwave Spectrum Analyzer available as a portable table-top unit. It can also be used for rack mounting by simply removing the top and side panels.

Other features of the Analyzer include simplified controls, flat face cathode ray tube with illuminated reticule, independent regulated Klystron power supply with DC filament source, fully regulated positive and negative DC supply and stabilized "safety" high voltage supply, and direct coupled Deflection Amplifiers for stable 2-20 cps sweep. Further information is contained in Technical Bulletin SA-40, available from the manufacturer.

Circle Reader Service Card 11

—mwj—

LOW NOISE DIODES FROM SYLVANIA

Maximum sensitivity with minimum noise has been made possible for microwave communications links, long range radar, telemetering, countermeasures and astronomy equipment by a new series of premium microwave mixer diodes announced by Sylvania Electric Products Inc., Woburn, Mass., a subsidiary of General Telephone & Electronics Corporation.

Roger A. Swanson, product sales manager—microwave diodes for Sylvania Semiconductor Division, said the new diodes employ "extremely tight electrical parameters" which result in overall noise figures.

Sylvania types 1N53C and 1N53RC are K_a-band (35,000 mc) diodes with a maximum overall noise figure of 9.0 db, 1 db better than their nearest counterpart.

Types 1N23F and 1N23RF are X-band (9375 mc) diodes with a maximum noise figure of 7.0 db, an improvement of 0.5 db over the 1N23E series with which they are interchangeable.

Types 1N21F and 1N21RF are designed for use at S-band (3000 mc) frequencies. They have a maximum overall noise figure of 6.0 db. This is 1.0 db better than their counterparts, with which they are interchangeable.

Circle Reader Service Card 11

—mwj—

RELIABLE BROAD BAND DUPLEXING

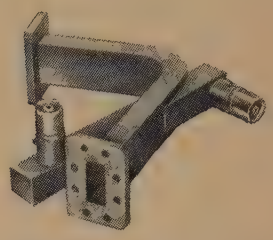
Tucor, Inc., South Norwalk, Conn., announces an advance in duplexer-design. This development is the result of improvements in TR and ATR Tubes, only recently made available thru Tucor. The new T4248VID Duplexer assembly, employing the important features of the previously announced T-42-U1 ATR and T-48-U1 TR tubes, will find broad application in medium power, branch type broad band duplexers.

Duplexer tubes in this new assembly utilize the new "electronic deionization" technique in lieu of the commonly used water vapor and rare gas mixture in competitive tube types. The Tucor design, proven by many successful applications and now available for general use, assures constant and predictable operating parameters for the lifetime of the tube.

(*Continued on page 84*)

Central's complete line of gas noise tubes, mounts and sources is *engineered* for both standard and custom applications in mind — *Engineered* for DC, AC or Pulse Operation — *Engineered* for replaceable tubes in most cases — *Engineered* to eliminate user tube aging — *Engineered* to occupy only a minimum of space and most of all — *Engineered* for reliability.

Complete Noise Source — CNS-V10E-2
Noise Output — 13 Db Tentative
Frequency — 50-75 KMc



Complete Noise Source — CNS-X20E-2
Noise Output — 14.6 ±.3 Db
Frequency — 8500-9600 Mc

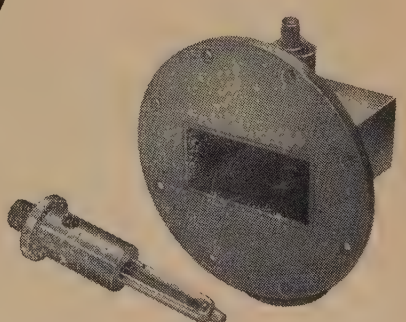
APPLICATION ENGINEERED GAS NOISE TUBES by Central

Central's gas noise tubes and sources offer a frequency range from 200 Mc to 75 KMc and firing voltages as low as 500 volts in both waveguide and coaxial types. Central's noise tube mounts are designed to give constant noise output over the specified band at lowest possible VSWR. Special designs customized to your requirements. Whatever your noise tube problem — see Central first!

Complete Noise Source — CNS-X20E-1
Noise Output — 14.6 ±.3 Db
Frequency — 8500-9600 Mc

Write for catalog 2240 describing all of Central's noise tubes, mounts and sources.

Central also makes power, pulse, rectifier and TR tubes, ionization gauges, and pressurized waveguide windows.



Complete Noise Source — CNM-S90E-1
Noise Output — 18.0 Db
Frequency — 2700-2900 Mc

Replacement tube type — CNT-S18P-3

NUCLEAR CORPORATION OF AMERICA

NUCOR

CENTRAL ELECTRONIC MANUFACTURERS

A Division of Nuclear Corporation of America

DENVILLE, NEW JERSEY

Export Department: 333 East 46th St., New York 17, N. Y.

Circle Reader Service Card 44

MICROWAVE COMPONENTS: Production and Related Data (1958)

Compiled by

Business & Defense Services Administration

U.S. DEPARTMENT OF COMMERCE

Microwave components are specialized electronic components designed to function at wavelengths of less than 1 meter (above 300 megacycles). The specialized microwave components covered by this study consist of the 43 categories shown in table 2 and fall into the following broad functional groups:

- Waveguides and fittings (bends, twists, flanges, etc.)
- Transitional and motional devices (rotary joints, coaxial to waveguide adapters, etc.)
- Microwave switches (coaxial and waveguide)
- Reactive devices (filters, phase shifters, modulators, etc.)
- Dissipative devices (attenuators, dummy loads, etc.)
- Hybrids (directional couplers, hybrid junctions, duplexers, etc.)
- Microwave test and measuring devices, NEC (probes, sliding loads, slotted lines, standard horns, etc.)
- Miscellaneous (holders and mounts, windows, etc.)

These components may be sold either as instruments or as integral portions of microwave systems. Most of the components are used between microwave antennas and transmitters or receivers, and more than a fourth of them are used for test or measurement at microwave frequencies. All of the components were divided into ferrite and nonferrite types in this study.

The microwave components included in the survey upon which this study is based comprised almost one-third of the estimated 1958 total value of shipments of all types of microwave components combined, as follows (in millions of dollars):

Microwave tubes	108
Microwave antennas	95
Microwave components covered in survey	92
Other (mixer crystals, etc.)	5
Total	300

The 96 establishments surveyed reported total shipments of $68.5 million, or about 75 percent of the $91.5 million estimated as the total output of the surveyed items throughout the electronic industries. The remaining 25 percent includes estimates for "captive" microwave components output, unreported research and development, and missing firms.

Although the 43 categories of components surveyed were produced by more than 200 establishments in 1958, many of these establishments conduct only small "captive" oper tions in support of their microwav antenna or electronic equipmer manufacturing activities. Less tha 50 establishments were engaged pr marily in microwave component pr duction during 1958, but these sp cialized facilities — several of whic were subsidiaries or divisions large electronic equipment or cor ponent firms — produced more tha half the total output. The remaind was produced as secondary produc by other types of electronic establis ments.

Microwave Component Manufacturing

Although some microwave cor ponent establishments produce a most exclusively on special orders to customer specifications (contra items) and others produce prin pally standard lines often referred as "catalog" items, most establis ments produce some quantity of bo types. Test and measuring compo ents are generally catalog items, a waveguides and related "plumbin components of electronic systems a typical contract-type components. few firms engage only in resear and development work and are n equipped for production.

(*Continued on page 72*)

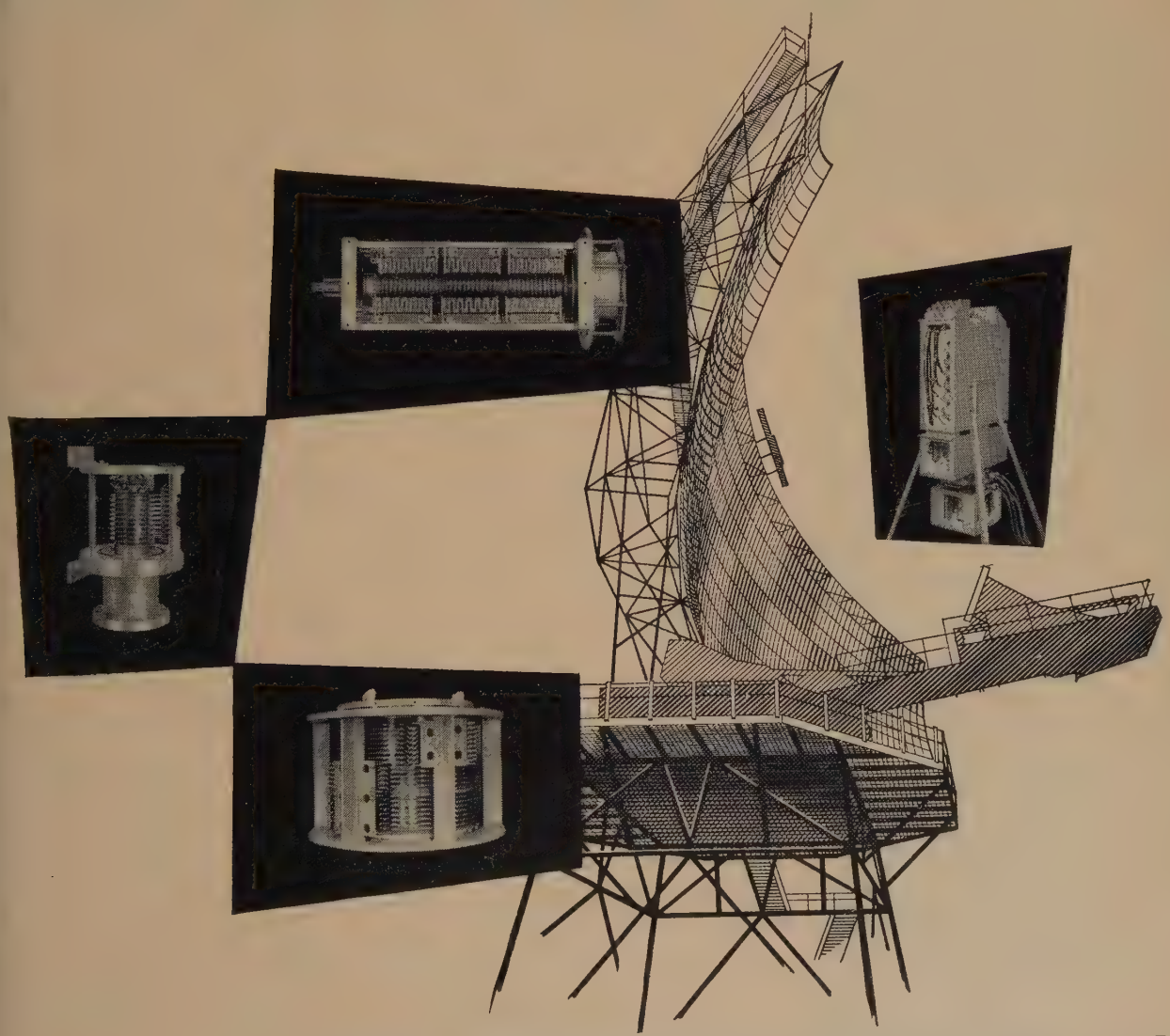
Thousands of Slip Ring Assemblies for Rotating Radar Antenna Systems

That's the Breeze Corporation's experience record in designing and producing slip ring assemblies for radar applications ranging from small shipboard and airborne antenna mounts to five-story-high giants used in ground early warning systems. With this experience record behind it, the Breeze organization is well-staffed and equipped to design and produce a slip ring assembly for any radar application.

Because many of these applications require assemblies having similar size and operating characteristics, Breeze offers a line of standard assemblies with ring envelope diameters from 1" through 10½". These are flat, stacked assemblies of fabricated construction and are built from off-the-shelf components for rapid delivery at reduced costs.

Breeze also produces flat, concentric and cylindrical custom slip ring assemblies for radar application requirements which include general purpose control and power, radio frequency and video, high voltage and switching. Depending upon the application, Breeze custom assemblies are made by any of the basic methods of production: fabricated, electroplated and plastic molded.

You'll want a copy of the new 28-page Catalog 66SR which describes and provides operating data on a wide range of Breeze custom units and drawings and specifications of all standard slip ring assemblies.



BREEZE MARK

BREEZE CORPORATIONS, INC.

700 Liberty Avenue, Union, New Jersey • Telephone: MUrdock 6-4000

Manufacturers of electrical, electro-mechanical and hydro-mechanical components and systems and fabricated metal products.

Circle Reader Service Card 45

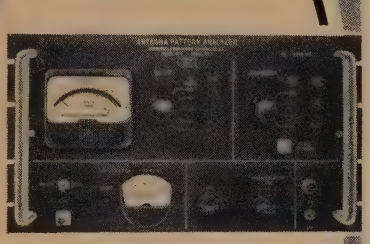
WEINSCHEL

ANTENNA PATTERN ANALYZER MODEL BA-7

Measure 45 db (r. f.) in one step using a maximum of 1 microwatt r. f. power*

*100% square wave modulated at 1000 cps ± .1 cps. Observation time approximately 45 seconds for 45 db; only .2 seconds for 30 db.

Bandwidth variable from 2 to 15 cps with constant gain



MODEL BA-7

The BA-7 is the heart of a video detector system designed primarily for r. f. crystals. For greater versatility, a. d. c. biasing circuit is included to permit use of conventional barretters, requiring a d. c. bias between 0 and 10 ma. The unit can be used to measure very high power ratios such as occur in making antenna pattern measurements, to determine the rejection coefficients of r. f. filters, and to calibrate attenuators. It has a wide dynamic linear range, a low noise level, and a wide r. f. frequency range where video crystal mounts are available.

For complete specifications, write for Bulletin No. 141.

Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12.4 KMC. Write for complete catalog, specifying frequency range of interest.

WE CO

Weinschel Engineering
KENSINGTON, MARYLAND

Circle Reader Service Card 46

BDSA Report

(*Continued from page 70*)

Manufacturers differ greatly in their degree of self-sufficiency. Some subcontract substantial portions of their manufacturing operations, but others are almost completely self-sufficient. Typical operations which are subcontracted include casting, plating, bending, machining, and precision grinding. Moreover, some manufacturers purchase piece parts such as flanges, couplings, bends, tubes, screw-machine products, and micrometer screw assemblies. Job shop subcontractors or parts vendors were not included in the survey because the value of their output was reported by the component manufacturers.

Covering as it does such a wide range of specialized products, this study can only describe manufacturing operations in very general terms. The principal operations are as follows:

- Product design
- Materials and parts procurement and inspection
- Precision casting
- Machining
- Brazing, welding, and soldering
- Cleaning and degreasing
- Plating
- Assembly of complex items
- Impregnation and painting
- Final test and calibration

Microwave components require extensive research and development, product design, and production engineering. Most items are produced in relatively short runs with general-purpose metal-working equipment capable of fabricating broad product lines. Almost all microwave component fabrication involves precision metalworking operations with close quality control. Most parts must be machined to close tolerances from purchased shapes and forms — aluminum, copper, and brass tubing, rods, and bars — or from precision castings. Piece parts are joined by standard brazing and welding techniques or by bolting together. Welded joints must be free of imperfections, and interior conducting and exterior mating surfaces must be machined to smooth, blemish-free, finishes. P cious metal or chromate plating used on conductive surfaces at high frequencies where surface attenu tion becomes a problem.

Complex microwave componen require precision assembly. A nu ber of components (sliding sectio waveguide frequency meters, var ble attenuators, etc.) contain pre sion micrometer screw assembl that are generally purchased. Finis ed components are attractively pai ed and labeled, "eye appeal" bei one of the characteristics sought the industry. All components recei extensive inline and final testin some require very accurate calib tion.

As in other electronics manuf turing, direct and indirect labor co are the largest element of microwa component manufacturing cos While labor costs vary from firm firm, 40 percent may be consider the median. Indirect labor costs a very high in this type of manufactu ing. Most manufacturers mainta substantial research and developm programs which require extensi engineering and supporting acti ties.

Data were not collected on eng eering manpower in the survey, b information from other sources dicates that the ratio of engine and scientists to total work force considerably higher in microwa component manufacturing than most electronic components ma facturing, and approaches that electronic end-equipment manuf turing. This high level of engine ing content is a characteristic of t type of activity and the major m sure of a firm's capabilities.

The proportion of skilled wo ers is also higher than in most el tronic components manufactur owing to the "custom" nature of products and the precision workm ship required. The principal skil occupations are:

- Tool and die makers
- Machinists
- Electronic technicians (engine ing, test and calibration)
- Instrument makers and precis assemblers (model shops)

With the exception of the me working trades, most of the skil workers are associated with eng

ng or with quality-control activi- such as testing and calibration.

Materials represent the next larg- proportion of total costs, rang- from 25 to 35 percent. As manu- urers differ widely in the amount work done on premises, the varie- nd degree of fabrication of in- ing materials varies considera- The major materials used are ollows:

luminum, brass, and OFHC cop- per waveguide tubing
rass, bronze, aluminum, and iron bars and rods
pecialty steel shapes and forms
crew machine and other small machine parts
astings
Micrometer tuning screw assem- blies
langes, joints, bends, and other piece parts
lating alloys

Manufacturers generally maintain 6 months' working inventories ubing and other basic materials sufficient stocks of purchased s, castings, screws, etc., to main- at least a month's production of log or common items. Specialty s for "contract" runs are pur- sed as needed. Materials are pur- sed to company specifications and ive incoming inspection, general- n a sampling basis, but with 100 ent inspection of the more criti- items.

The nature of a microwave com- ents manufacturer's facilities de- ds upon the size of the firm, its me of output, and the relation- of work done on premises to subcontracted. As a result, d charges (rent, depreciation, rtization, etc.) may range from 10 percent of total costs. Most ducers have a relatively large in- ment in electronic test and mea- ng equipment and model shop lities for use in research and de- pment (R&D) activities. In y establishments the investment electronic test and calibration ipment required for R&D and duct testing and calibration far weighs the investment in produc- tooling.

Fully integrated, self-sufficient microwave components establishments may have all of the following types of tools and equipment:

General-purpose machine tools
Special-purpose machine tools
Welding and brazing equipment
Impregnation equipment
Cleaning equipment
Bending equipment
Screw machines
Foundry
Plating facilities
Electronic test and calibration equipment

All establishments have some machine tools. Most tools are general purpose, but some of the larger producers have some special-purpose tools. Small producers generally subcontract foundry, plating, and certain other operations rather than invest in equipment which would not be used extensively.

Marketing practices are fairly consistent among microwave components companies. Manufacturers sell most of their standard catalog items through manufacturers' representatives, although some reserve territories adjacent to their plants for direct sales. As in other electronics manufacturing, there is a tendency for companies to establish their own sales organizations as their business grows. Sales of contract-type components require close liaison with systems manufacturers, which is maintained through personal contacts, sales representatives following contract awards, and the use of direct-mail advertising. Export sales, which are handed through export representatives, are relatively small and go predominantly to Europe. Imports are insignificant in volume.

Microwave components manufacturers conduct substantial advertising programs, both product and institutional, in electronics technical publications read by design engineers. Most companies also make extensive use of direct-mail advertising.

(*Continued on page 74*)

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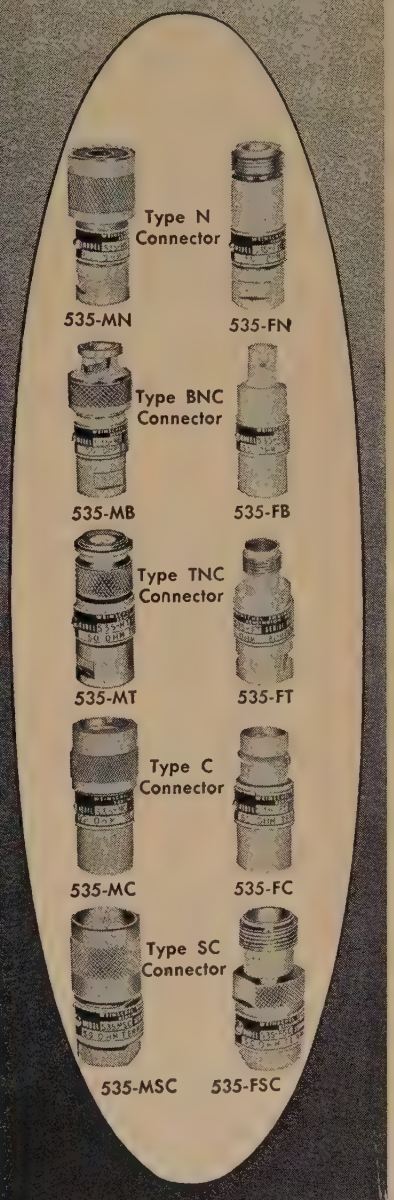
COAXIAL TERMINATIONS

DC to 10 KMC
50 ohms

Connectors: N, C, SC, BNC and TNC
Individual VSWR calibrations supplied at seven frequencies: DC, .4, 1, 2, 4, 7.5 and 10 KMC.
Made with Weinschel Film Resistors for maximum stability.



Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12.4 KMC. Write for complete catalog

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Weinschel Engineering
KENSINGTON, MARYLAND

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(*Continued from page 73*)

Analysis of Survey Results

Summary results of the survey are shown in table 1 and include estimates for missing firms. As the table indicates, unfilled orders at the end of 1958 were more than 50 percent of total 1958 shipments, and year-end inventories were only 12 percent of 1958 shipments. Plant visits in late 1959 revealed that 1959 output levels were substantially above those of 1958 and indicated that 1960 would bring further expansion.

Detailed results of the survey are shown in table 2. Unlike table 1, however, table 2 shows only totals of shipments reported by the 96 establishments whose schedules were tabulated in the survey. For several reasons, detailed estimates, by product, could not be made for national output as a whole, as was done in table 1 for survey totals. Unreported research and development activity was largely concentrated in new items or items requiring high technology. Conversely, the "captive" production not covered by the survey was heavily concentrated in volume items, such as waveguides and fittings. Unreported production in microwave antenna establishments was also concentrated in items associated with antennas—such as horns, antennas, waveguide feeds and fittings, rotary joints, etc.

As anticipated, almost 80 percent of total shipments were for military end use. Ferrite microwave components, which are still emerging gradually from R&D, amounted to less than 6 percent of the total. Table 2 indicates the high unit value of most microwave components.

Most microwave components produced in small establishments. table 3 shows, over half the do value of shipments reported in survey emanated from establishm employing an average of fewer t 250 employees in 1958 and over percent from those employing fe than 500 employees. Less than 9 p cent of total shipments were rep ed by establishments employing m than 1,000 workers and these lar establishments were equipme manufacturers producing largely their own use. If all equipment other "captive" producers had b

Table 1 — Salient data for microwave components: E mated totals, 1958

Total shipments	$91,500,(
Unfilled orders as of December 31, 1958	51,600,(
Inventories as of December 31, 1958	11,100,(
Plant space used for production as of December 31, 1958 (square feet)	1,830,(
Average employment engaged in production[1]	8,7

[1]Estimated from annual-shipments-per-employee data computed from reports from spe ized microwave component establishments.

Table 2 — Shipments of specified microwave components during 1958 as reported by principal manufacturers[1]

Product	Average unit price	Total shipments		Military		Nonmilitary	
		Number of units	Value ($1,000)	Number of units	Value ($1,000)	Number of units	Value ($1,000)
Microwave components, except ferrite devices and tubes:							
Attenuators	$76.10	48,004	$3,654	29,327	$2,129	18,677	$1,5
Bends and twists	15.50	115,645	1,797	109,242	1,494	6,403	3
Bolometers	17.00	27,632	463	23,734	404	3,898	
Cavity frequency meters	377.50	8,054	3,041	6,215	2,560	1,839	4
Delay lines	234.00	560	131	518	120	42	
Diplexers	495.00	767	380	691	316	76	
Directional couplers	81.00	38,225	3,106	29,574	2,440	8,651	6
Dummy loads	128.00	15,579	1,987	12,635	1,732	2,944	2
Duplexers, except tubes	100.00	29,227	2,925	27,010	2,720	2,217	2
Filters	45.00	51,953	2,325	46,432	1,958	5,521	3
Flanges and couplings	5.00	228,696	1,171	188,758	962	39,938	2
Gyrators	.....	.....	.....	.....	.....	.....	.....
Holders and mounts (bolometer, crystal, thermistor, etc.)	54.50	31,945	1,743	24,486	985	7,459	7
Horns (standard gain, ridged horns, etc.)	119.00	11,648	1,384	9,095	1,043	2,553	3
Hybrid junctions (T's, L's, folded hybrids, etc.)	218.00	10,579	2,304	8,856	2,096	1,723	2
Isolators	177.00	820	145	549	64	271	
Limiters	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Magnetron test plumbing, n.e.c.	584.00	154	90	120	87	34	
Modulators	1,770.00	668	1,182	109	419	559	7
Phase shifters	188.00	3,897	734	3,263	603	634	1

See footnotes at end of table.

Table 2 — Shipments of specified microwave components during 1958 as reported by 96 principal manufacturers[1] — (Cont.)

Product	Average unit price	Total shipments		Military		Nonmilitary	
		Number of units	Value ($1,000)	Number of units	Value ($1,000)	Number of units	Value ($1,000)
Microwave components, etc.--Con.							
Printed microwave components	737.00	787	580	742	304	45	276
Probes	60.00	1,962	117	1,629	75	333	42
Reflections, standard	181.00	843	153	243	46	600	107
Rotary joints and sector scan joints	333.50	10,840	3,616	5,158	2,948	5,682	668
Shutters	174.00	471	82	429	73	42	9
Sliding loads, shorts, etc.	75.50	4,730	357	2,137	226	2,593	131
Slotted lines	245.00	3,933	964	1,237	418	2,696	546
Switches, coaxial and waveguide	143.00	33,930	4,850	14,602	3,886	19,328	964
Terminations (high and low power, etc.)	62.00	8,925	554	5,547	419	3,378	135
Transitions (coaxial to waveguide adapters, etc.)	72.00	24,448	1,770	16,567	1,484	4,881	226
Tuners (coaxial and waveguide, E and H plane, stub, slide screw, etc.)	129.00	8,688	1,125	2,858	871	5,830	254
Waveguides, rigid and flexible	33.00	300,016	9,954	259,028	7,936	40,988	2,018
Windows	21.50	4,728	102	4,060	84	668	18
Other[3]	.....	70,541	11,917	65,084	10,661	5,457	1,256
Total, nonferrite	.....	.....	64,670	.....	51,563	.....	13,107
Ferrite microwave components:							
Attentuators	128.00	288	37	88	29	200	8
Circulators	294.00	432	127	177	61	255	66
Duplexers	274.00	930	255	74	105	856	150
Gyrators	.....	.....	.....	.....	.....	.....	.....
Isolators	127.00	18,635	2,363	13,535	1,742	5,100	621
Limiters	.....	.....	.....	.....	.....	.....	.....
Modulators	382.00	532	203	327	161	205	42
Phase shifters	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Switches	541.00	61	33	56	31	5	2
Other[4]	.....	3,750	758	2,190	506	1,560	252
Total, ferrite	.....	.....	3,776	.....	2,635	.....	1,141
Grand total, ferrite and nonferrite	.....	.....	68,446	.....	54,198	.....	14,248

[1]Total shipments of each component category reported by the 96 plants of microwave components manufacturers whose schedules were tabulated in the survey. Industry-wide estimates cannot be made for this level of detail.

[2]Not shown to avoid disclosure of proprietary information but included in "other," subtotals, and grand totals.

[3]The principal items reported on this line were, in order of their value of shipments:

Microwave antenna components
Coaxial tuned cavities
Mixers and mixer arrays
RF coaxial wattmeters
Hybrid junctions
Test equipment (not identified further)
Component systems
Linear/circular polarizers
Waveguide tubing
Preselectors and RF oscillators
Power meters
Waveguide assemblies
Combination waveguide components
Crystal mixers and power dividers
Metalized attenuators
Amplifier cavities

The combined total value of shipments reported for these items was $10,588,000, or 90 percent of the total value of shipments reported in "other." Several of these items should have been included in some of the 33 preceding specific categories printed on the form.

[4]The principal items reported on this line were, in order of their value of shipments:

Special ferrite devices (not identified further)
Antenna mixers
Equalizers and harmonic suppressors
Research on ferrite components

The combined value of shipments reported for these items was $640,000, or 85 percent of the total value of shipments reported in "other."

(*Continued on page 76*)

MICRO-MINIATURE
"DELTA"
WAVEGUIDE
SWITCH

A complete family of switches available in over 40 models

- EXTREMELY COMPACT & RUGGED
- WEIGHT 1.2 oz. to 4 lbs.
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- "FAIL-SAFE"
- FROM "L" TO "Q" BAND (2.6 to 50.0 KMC)
- AC or DC OPERATION
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division of Regan Industries, Inc.

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Table 3 — Microwave component shipments, unfilled o ders, and inventories, by size of establishmen 1958

Number of establish-ments	Number of employees	Percent of total micro-wave com-ponent shipments	Percent of total microwave component shipments for military end use	Unfilled orders as a percent of annual shipments[1]	Inventories as a percent of annual shipments[1]	Degree specializ zation[2]
14	1-19	2.6	93.5	409.0	13.2	7
19	20-49	8.7	71.3	39.6	9.7	7
14	50-99	12.4	80.3	28.6	9.8	6
21	100-249	29.2	80.0	53.4	13.4	4
10	250-499	23.2	83.3	71.4	20.6	3
10	500-999	15.2	81.1	30.7	4.0	1
4	1,000-2,499	6.3	54.0	27.6	2.4	
4	2,500 and over	2.4	90.7	23.0	12.7	
96	Total or average	100.0	79.4	56.8	12.2	1

[1]As of December 31, 1958.
[2]As measured by the ratio of the value of the establishments' microwave component shipments to thei total shipments.

included in the survey, the concentration of output in small establishments would have been reduced significantly, but the preponderance would still have been from establishments with fewer than 500 employees. As would be expected, the degree of specialization — as measured by the ratio of microwave component shipments to total shipments — varied inversely with size of establishment; but even small esta lishments produced a substantial v ume of other products. These we generally related products, such assembled microwave test and me uring equipments which were not cluded in the scope of the surv There were no significant variatio in the proportion of total shipme for military end use by size of est lishments. Unfilled orders were re tively greater in volume in mediu size establishments than in large a small ones.

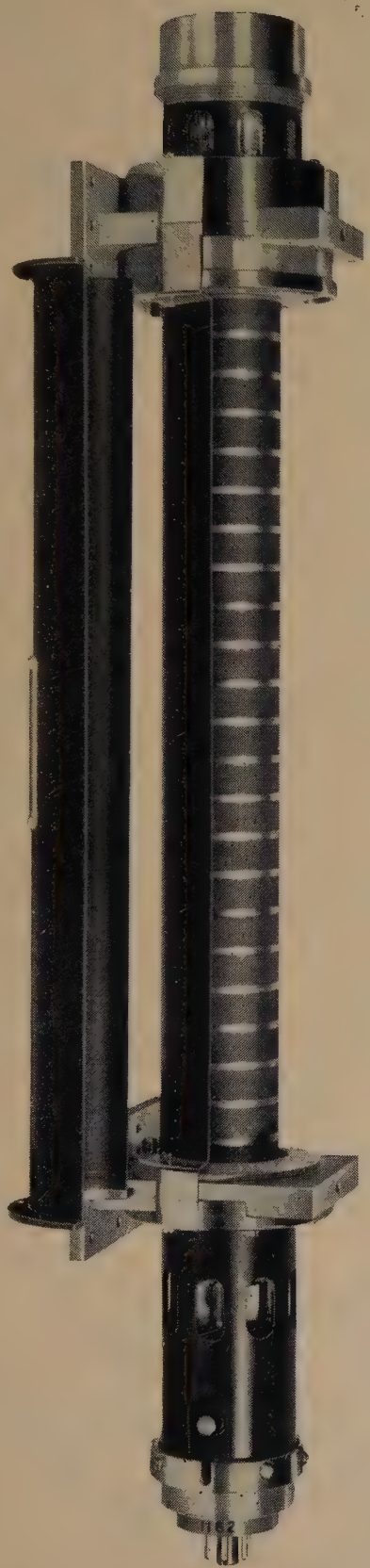
Microwave components manuf turing is heavily concentrated in t New York metropolitan area, wh contributed 54 percent of the to shipments reported in the sur (table 4). Three other areas — B ton, Los Angeles, and San Francis — contributed an additional 20 p cent. The remaining 26 perc came from several other metrop tan areas which could not be sho separately because to do so wo reveal proprietary information. I highly significant that three-four of the producers are clustered arou educational centers which have ma some of the greatest contributions the advancement of the microw arts. More than 80 percent of t shipments originated in five Sta New York, New Jersey, Califor Massachusetts, and Connecticut.

As table 4 indicates, there w significant differences between a in the ratios of unfilled orders inventories to shipments, the

(*Continued on page 78*)

Circle Reader Service Card 49

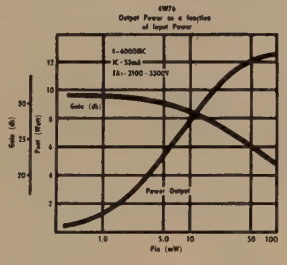
package-type TWT power amplifiers with NEC's new long life cathode



Production of traveling wave tubes at NEC began seven years ago and introduction of the package-type three years later. As chief supplier to Japan's complex network of microwave communications, NEC has become the world's largest maker of TW tubes. With the high development costs amortized and large manufacturing capacity, NEC is now able to supply these tubes at well below usual prices.

NEC's new doped nickel cathode core material, a 10-year development, increases both emission and tube life. It has been thoroughly field-proven in disc-sealed planar triodes for 2000-mc equipment of a large U.S. systems manufacturer (name on request). With its cooler operating temperature, evaporation rate of oxide is less than any other known core materials. This extends tube life up to 50%.

Designers will appreciate the compactness these tubes will give to their systems and operators the reliability and economy. Tubes connect to standard IEC waveguide flanges and can be shipped from stock. For specifications sheets, please write to Tokyo.



4W76

The 4W76 operates in the 4000-mc band and has nominal saturated power output of 10 watts. High amplification over a wide range of power levels results in small-signal gain of approx. 30 db. The band width at half-power points is 1400 mc, but the tube can be used in the frequency range of 2800 to 5000 mc.

Typical Operating Characteristics at 4000 mc

First Anode Voltage	2,640 V	Saturated Power Output	12.5 watts
Helix Voltage	3,220 V	Small-Signal Gain	32 db
Helix Current	0.7 mA	Noise Figure	approx. 25 db
Collector Current	33 mA	VSWR	less than 2 to 1 (from 3500 to 4300 mc)
Focusing Electrode Voltage	−40 V		

NEC TRAVELING-WAVE AMPLIFIERS

PERMANENT MAGNET FOCUSED AMPLIFIERS

4W75	4000-mc band	1.5 watts	8W75	7000-mc band	1.5 watts
4W76	" "	5-10 watts	8W76	" "	5-10 watts
6W50	6000-mc band	5-10 watts	11W17	11000-mc band	1.0 watt

ELECTROMAGNET FOCUSED AMPLIFIERS

4W85	4000-mc band	0.1 watt	4W72A	4000-mc band	1.5 watts
4W86	" "	1.0 watt	7W52	6000-mc band	5-10 watts

Advantages of package-type

NO focusing or impedance matching at installation
NO dummy space for removal
NO power source or current stabilizer for electromagnet

NEC *Nippon Electric Company Ltd.* Tokyo, Japan

COMPONENTS / SYSTEMS

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COMMUNICATION TOWER

(This radar weather tower of KSTP-TV, Minneapolis, uses the 3 lower sections of the ROHN "Self-Supporting" tower. Note construction, design and size.)

HERE ARE THE HIGHLIGHTS OF THE ROHN "SS" TOWER:

- ★ 130 ft. in height, fully self-supporting!
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- ★ Complete hot-dipped galvanizing after fabrication.
- ★ Low in cost—does your job with BIG savings—yet has excellent construction and unexcelled design! Easily shipped and quickly installed.

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ROHN *Manufacturing Co.*

116 Limestone, Bellevue, Peoria, Illinois

"Pioneer Manufacturers of Towers of All Kinds"

BDSA Report

(*Continued from page 76*)

portion of shipments for military end use, and the degree of specialization in the manufacture of the components covered by this survey. Most of the firms specializing in microwave components are located in the New York and Boston metropolitan areas. Microwave components produced in other areas are usually secondary products.

Output of microwave componen has expanded greatly during the pa 10 years. Although data are n available to measure growth rat the histories of a few of the larg firms suggest that this segment of t electronic industries has expand more rapidly than the industries as group.

Special tabulations were made obtain certain averages or "norm

(*Continued on page 81*)

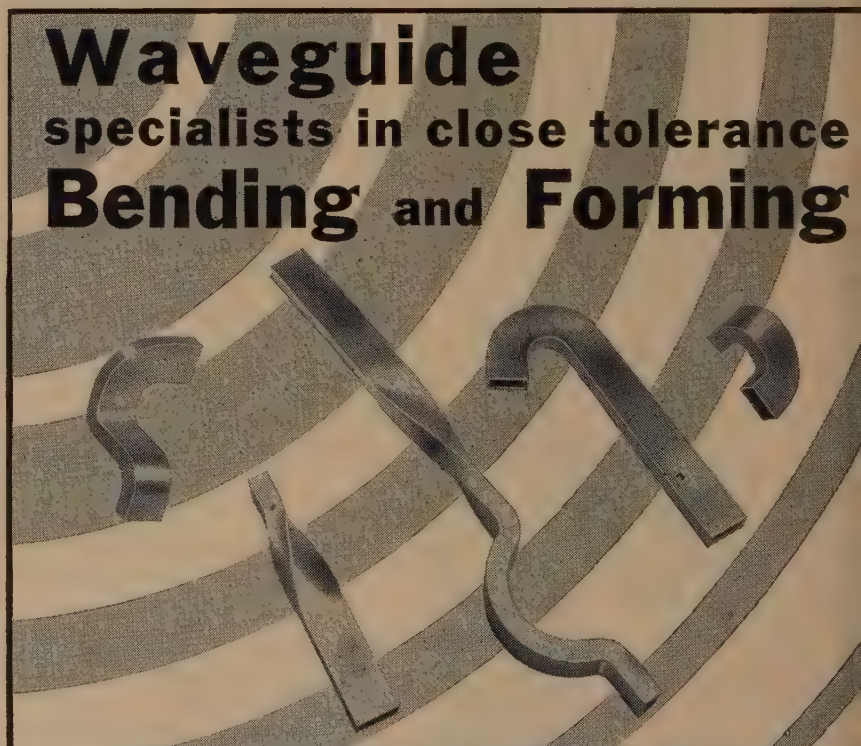
Table 4 — Origin of shipments of microwave component and related information, by metropolitan area 1958

Number of establishments	Metropolitan area	Percent of total microwave component shipments	Percent of total microwave component shipments for military end use	Unfilled orders as a percent of annual shipments[1]	Inventories as a percent of annual shipments[1]	Degree of specialization[2]
24	New York City	37.6	90.0	54.7	8.0	48.
9	Newark	16.3	79.3	43.6	10.7	70.
11	Los Angeles	8.0	62.7	100.2	8.2	8.
19	Boston	7.8	82.5	51.5	10.6	87.
6	San Francisco	4.3	25.8	24.4	4.6	5.
27	All others[3]	26.0	76.6	61.2	21.0	5.
96	Total or average	100.0	79.4	56.8	12.2	12.

[1] As of December 31, 1958.

[2] As measured by the ratio of the value of the establishments' microwave component shipments to their total shipments.

[3] Includes several areas with substantial microwave component shipments which cannot be shown separately without disclosing information on individual firms.



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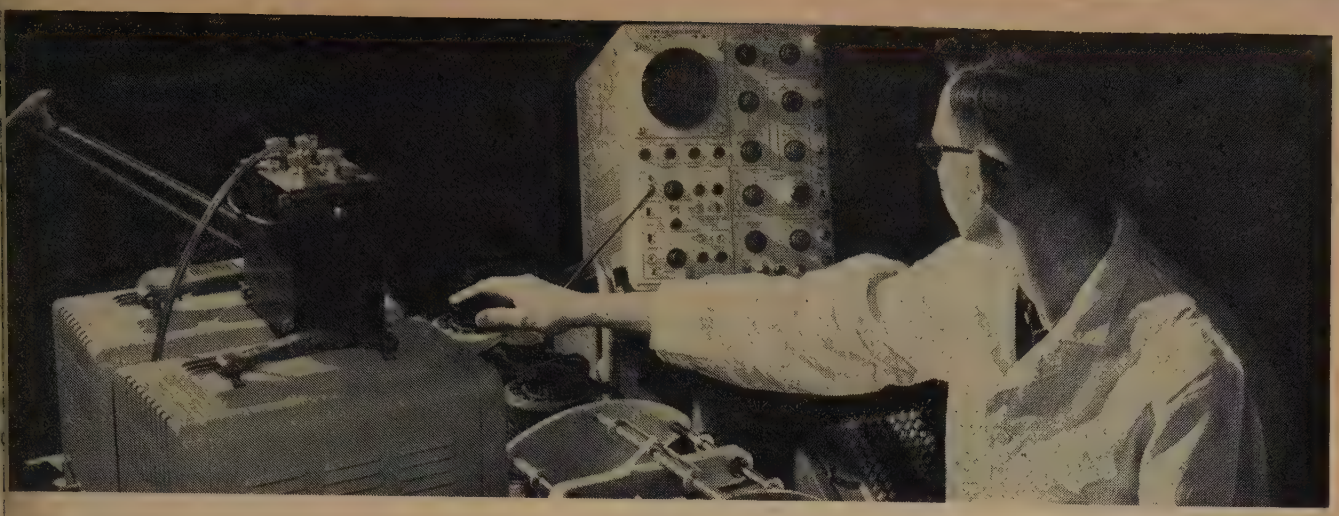

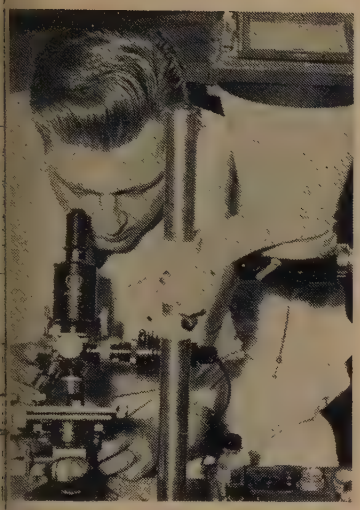

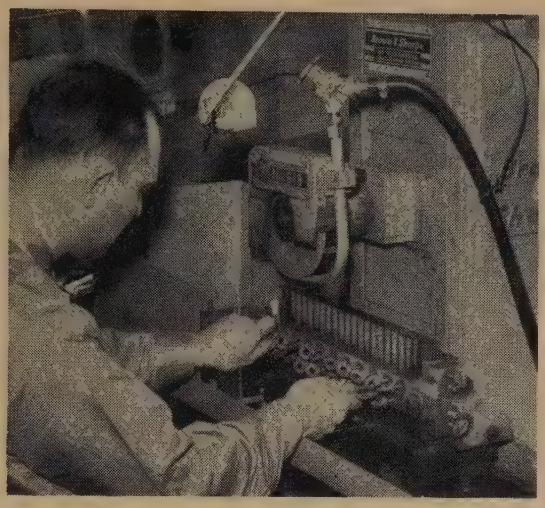

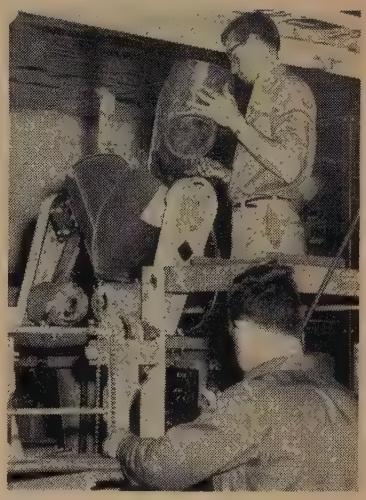

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MODEL 630-X

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POWER OUTPUT:	20 MW (Minimum)
SWEEP RATE:	C. W. or 0.1-100 CPS
SWEEP WIDTH:	A few MC to 4.2 KMC
A. M. MODULATION:	800-1200 CPS Sq. Wave
SWEEP OUTPUT:	Linear Sawtooth
OSCILLATOR:	Varian VA-161
SIZE:	7″ x 19″ x 13″
WEIGHT:	Approx. 25 lbs.
R. F. CONNECTOR:	Type "N" (Female)
PRIMARY POWER:	105-125/1/60
PRICE:	$2,850.00
RACK MOUNT:	$2,825.00
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(*Continued from page 78*)

Table 5 — Summary data on 43 microwave component manufacturing establishments[1] (In thousands of dollars unless otherwise indicated)

Item	Total, 43 establishments	7 establishments specializing in "catalog" items[2]	36 other establishments[3]	5 ferrite microwave component establishments[4]
tal plant shipments	48,893	12,174	36,719	2,182
crowave component shipments	42,712	7,823	34,889	2,182
litary microwave component shipments	33,483	4,853	28,630	1,720
ximum capacity	139,307	25,775	113,532	4,578
filled orders on 12/31/58	18,690	1,480	17,210	838
ventories as of 12/31/58	6,083	942	5,141	248
tal plant floorspace.....square feet..	1,029,231	210,500	888,231	49,177
crowave component floorspace.....square feet..	851,279	196,000	655,279	39,533
ployment.....number..	4,648	1,017	3,631	197

[1]Establishments selected because microwave components comprise almost all of their total output.
[2]Establishments whose total shipments comprise a high proportion of proprietary-designed standard ems, produced for or sold from inventory.
[3]Establishments engaged primarily in producing special-design microwave components ("contract" items); cludes the 5 ferrite establishments.
[4]Establishments engaged predominantly in producing ferrite microwave components.

r microwave components manufacre and to determine whether there ere significant differences between fferent types of firms. For this purse, 43 establishments were selected hich were engaged almost entirely microwave components manufacring. Those establishments proced over half the total 1958 esnated output of these products, d components included in the surly accounted for 87 percent of eir total value of shipments. The sults of these tabulations may be nsidered typical of microwave mponent manufacturing in view of e size of the sample and its freedom m the influence of other procts. The sample totals are conned in table 5 and the averages "norms" in table 6.

Analysis of the results indicates t microwave component produc- shipped about $10,500 worth of ducts per employee in 1958 — stantially above the all-compon- s average of about $9,100. This pments-per-employee ratio is alst identical with that for transmitg and special-purpose tubes. Alst 80 percent of the output of se establishments as a group was military applications. Operations re at only 30 percent of estimated ximum capacity with existing nt and equipment. (The assumpns which manufacturers were ask- to use in estimating their capacity shown on the report form reduced on page 13.) As a group, se establishments had about 225 are feet of floor space per emyee, including space occupied by ces, research and development as, materials storage, finished-prot inventories, and other supporting activities. This space per employee is almost double the average for all other electronic components combined. Unfilled orders at year-end were about 44 percent of annual production, or over 5 months' production backlog. Year-end finished component inventories were only 14 per cent of annual shipments, or equivalent to about 7 weeks' sales. These figures reflect the general increase in electronics output experienced during 1959.

Within the sample group there were five establishments specializing in manufacturing ferrite microwave components. As table 6 indicates, their value of output per employee was substantially higher than that of other microwave components producers. They also had more floor space per employee, their value of unfilled orders was higher, and their finished component inventories were lower. These differences probably resulted from the relatively greater research and development activities of microwave ferrite component producers and from their materials-processing activities.

The seven establishments in the sample which were engaged primarily in producing catalog-type items showed annual shipments per employee of $12,000, 20 percent above those of other establishments. As expected, their proportion of total output for military end use was well below that of other producers but still represented over 60 percent of their total shipments. Surprisingly, the catalog component group's inventory-to-sales ratio was actually lower than that of the 36 other establish-

(*Continued on page 82*)

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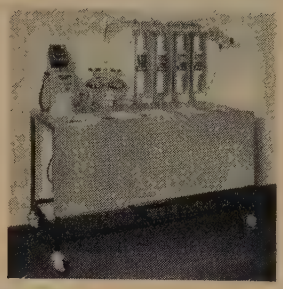

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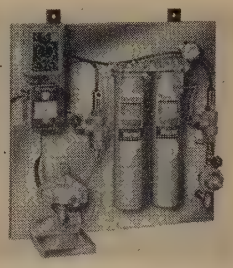

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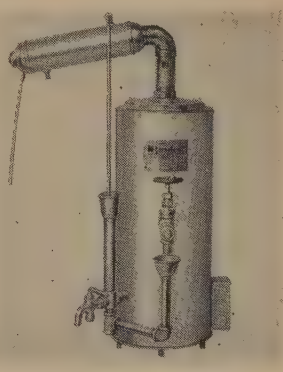

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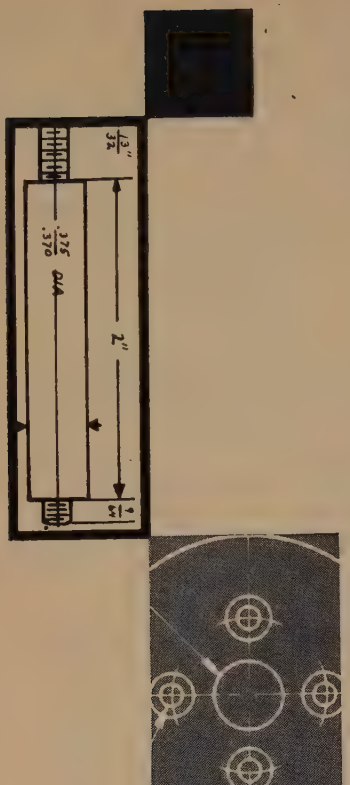

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BDSA Report

(*Contiued from page 81*)

ments. (The results of this comparison might have been different if catalog-type component shipments had been completely separated from special-order items.) As in the case of ferrite components, the seven catalog establishments were heavily engaged in R&D, most of the firms being recognized leaders in microwave technology.

Survey Techniques and Limitations

This study of microwave components was based on a mandatory mail survey conducted from April to September 1959. The reporting categories were developed by the Electronics Division, BDSA, after consultation with Government and industry officials. This division also designed the schedule (see facsimile on p. 13) with assistance of the Bureau of the Census and departmental officials. In preparing the mailing list, every attempt was made to include all significant producers. After selecting well-known producers, a thorough search was made of advertising literature and trade directories for additional firms. The resulting list and reporting categories were then coordinated with industry members during the 1959 Institute of Radio Engineers National Convention and Trade Show in New York as well as with officials of other Government agencies.

The Bureau of the Census mailed out the schedules to 141 establishments, assisted in follow-up contacts, and tabulated the data. The Electronics Division, BDSA, edited the schedules, contacted late respondents, designed the tabulations, and analyzed the data. Data tabulations were postponed until every respondent either submitted a schedule or was determined to be outside the scope of the survey.

Of the 141 establishments contacted in the survey, 96 reported significant microwave component shipments during 1958. The remaining 45 establishments were excluded from the major tabulations for the following reasons:

- No longer in business
- Did not make microwave components during 1958
- Engaged only in research and development
- New firms which commenced operations late in 1958 or in 1959

Schedules of the latter two types r respondents were tabulated separat ly since the inclusion of these firn would have distorted the results the survey. This information w used in estimating industry totals.

The firms' averages or ratios, di cussed earlier, were derived fro special tabulations made by BDS of schedules of establishments wi a high degree of specialization in m crowave components productio (For example, microwave compo ents comprised 87 percent of the t tal value of shipments from the establishments selected for speci tabulations.) These establishmen accounted for more than 50 perce of total estimated 1958 microwa components shipments, so the i formation derived from them can considered both reliable and typic of microwave component produ tion.

The data derived from this stu are subject to several limitations. M crowave components are extreme difficult to categorize, as there is universally accepted terminolo throughout industry. Although su stantial effort was devoted to the d velopment of reporting categori manufacturers use different termi ology for the same components apply the same terms to differe components. The detailed shipmen data in table 2 are, therefore, less r liable than those for total shipmen owing to reporting variations.

Microwave antennas were exclu ed from the survey because their i clusion would have almost doubl the number of respondents. Th may not have been the most desir ble approach, because antenna sy tems generally contain some of t microwave "plumbing" and oth microwave components included the survey. Some of these items a made by antenna manufacturers f their systems or for sale as compo ents. Moreover, most microwa components are either associat with antenna system or are used f output measurements so that would have been desirable to ha comparable figures on output microwave antennas. All anten manufacturers who were known produce other microwave compo ents for sale were included in the su vey and this information was used estimate "captive" microwave co ponent output of other antenna fir not included in the survey.

able 6 — Microwave component ratios or averages derived from reports from 43 selected microwave component establishments[1]

Item	Total, 43 establishments	7 establishments specializing in "catalog" items	36 other establishments	5 ferrite microwave component establishments
nual shipments per employee	$10,500	$12,000	$10,100	$11,100
oorspace per employee.....square feet	226	207	244	249
crowave component shipments as a percent of total hipments	87	84	95	100
rcent of total microwave component shipments sold or military applications	78	62	82	79
rcent of total capacity utilized during 1958	31	30	31	48
filled orders on 12/31/58 as a percent of 1958 icrowave component shipments	44	19	49	38
ventories of finished microwave components on 2/31/58 as a percent of 1958 microwave component hipments	14	12	15	11

[1]Selected as outlined in the footnotes in table 5.

Equipment manufacturers also oduce some microwave compon- ts for inclusion in their electronic stems or for sale as components. ne size of this "captive" market s estimated by techniques similar those outlined above, since it was ipractical to survey hundreds of uipment establishments. Several uipment manufacturers known to manufacturing significant quanti- s of microwave components, either their own use or for sale, were cluded in the survey and this in- rmation was used in estimating to- "captive" microwave components tput by all equipment manufactur- .

Another major limitation was the nission of a separate section in the rm for manufacturers to report eir research and development ac- ities. Information derived from hedule editing, follow-up contacts, d field work revealed that research d development activities constitu- l a substantial part of total micro- ve components activities. Some spondents reported these activities parately under "other" microwave mponents, some apparently made distinction between research and velopment contract billings and her shipments, and others did not port research and development llings or shipments. Several es- blishments reported that they were gaged entirely in microwave com- nents research and development tivities. Schedules from these es- blishments were tabulated separ- ely so as not to distort the industry erages derived from the survey. ese data were used, along with her information on microwave mponents research and develop- ent, to estimate total microwave mponents research and develop- ent activity throughout the econo- y.

Despite every effort to include all specialized microwave component establishments in the survey, some small firms were probably omitted, so a small allowance was made for them in estimating industry totals.

In view of the fact that some establishments subcontract substantial proportions of their manufacturing operations, such as machining, plating, brazing, etc., integrated self-sufficient firms should exercise caution in using the averages derived from this survey as a norm in evaluating their own operations.

Unfortunately, there were no benchmarks, such as Census of Manufactures data, that could be used to check the accuracy of the estimates made in this report for captive production, unreported research and development activity, or shipments of missing firms in deriving the industry totals contained in the report. These estimates, which comprise about 25 percent of total microwave components shipments, were as follows:

"Captive" microwave components output	$13.0 million
Unreported research and development shipments or billings	$7.0 million
Shipments from missing firms	$3.0 million

The survey schedule did not make any distinction between shipments of catalog-type items and other microwave components shipments that would have provided additional marketing information desired by microwave components producers. Future surveys in this area should provide this information.

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New Products

(*Continued from page 68*)

The T4248VID Duplexer will cover UHF frequencies from 225-400 mc and is capable of reliable operation at 1 KW peak power input or 400 watts average. Construction is of rigid coaxial line with RF output connections by way of Type N or 7/8" coaxial fittings. VSWR is held to 1.5 on transmit and 1.7 on receive. Careful selection of components and careful construction has resulted in an assembly developing no more than 0.6 db insertion loss. Models covering higher or lower frequencies and power ratings can be provided.

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— mwj —

NEW HIGH POWER X-BAND DUMMY LOADS

A new high power X-band dummy load has been introduced by Airtron Pacific, Los Angeles, Cal., a division of Litton Industries. Designated Model 890379, this dummy load is smaller and lighter than loads previously available for X-band radars.

Designed to operate with RG51/U waveguide, with an outside dimension of 5/8 x 1 1/4, the new load can be used in any radar operating between 7050 to 10,000 mcs.

Up to 600 watts of average power and 460 KW of peak power can be dissipated without liquid cooling. Maximum VSWR is 1.10 over the frequency band.

Using inert Silicon Carbide as the absorptive element, moisture absorption is negligible. Designed for use under rugged environmental conditions, the new load meets the requirements of MIL D 14454 and MIL E 5272.

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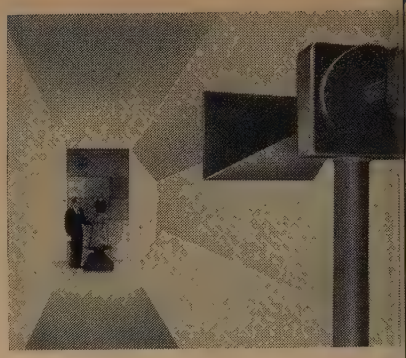
— mwj —

INDOOR ANTENNA PATTERN TESTING RANGE

The completion of a new microwave antenna pattern range that provides greater testing accuracy and efficiency because it operates entirely indoors, has been announced by Mr. Budd Meyers, General Manager of the Budd-Stanley Company, Long Island City, N.Y., designers and manufacturers of microwave transmission equipment.

Unlike outdoor ranges, with uncontrollable weather, radiation noise and other interference variables, the new Budd-Stanley indoor range permits more precise antenna measurements because test conditions are constant and outside interference is completely eliminated. The indoor range also puts system and antenna production on an efficient, planned



basis. Antenna tests can be conduct round-the-clock, no matter what t weather, in contrast to outdoor rang which operate only in fair weather.

The new Budd-Stanley indoor ran gives reliable performance data for bo one-way and two-way microwave anten pattern measurements from 2,500 to 2 500 mcs. An 11-foot octagon in cro section and about 40 feet in length, t range measures antennas with a gain to 30 db in both azimuth and elevati planes. Associated electronic gear, i cluding a rectangular coordinate patte recorder, assures precise analysis of t patterns obtained.

The new indoor range was develop by Budd-Stanley with the assistance Mr. Howard Jones of the Diamo Ordnance Fuze Laboratories, Washingto D.C. "The testing we have done to da has proven the reliability and accura of our new indoor range. We are pla ning to make this indoor range availab to the industry for antenna producti testing and for research and developme work," Mr. Meyers reported.

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— mwj —

LITERATURE . . .

STANDING WAVE AMPLIFIER

Latest issue of "New From PRI describes the PRD 277-B Standing Wa Amplifier, a specially designed high ga audio amplifier to be used with slott sections in making standing wave me urements.

The two-page bulletin lists spec features and details performance char teristics such as frequency, sensitivi noise level, bandwidth, attenuation ran and power.

Weak signals which once were u detected by conventional instruments c now be measured by the PRD 277-B. A tenuation in 5 db steps combined with VSWR scales and a large meter perm VSWR measurements to be made with treme accuracy.

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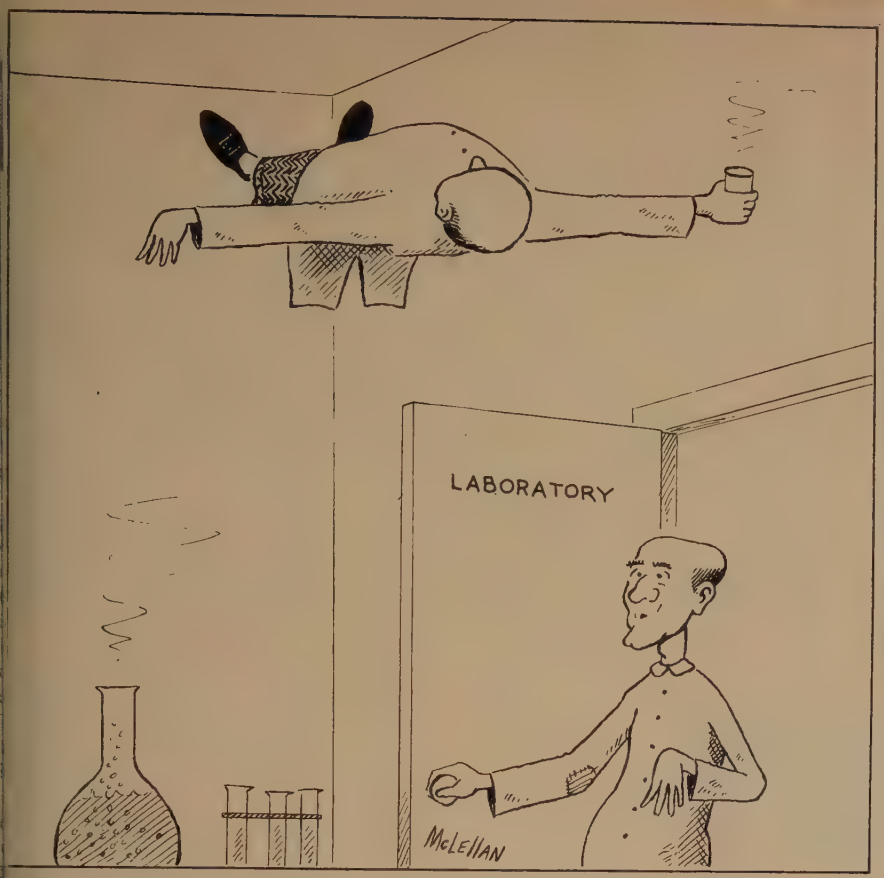
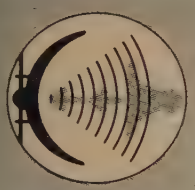
(*Continued on page 87*)



"Dr. Freebish, how did your anti-gravitation experiment work out?"



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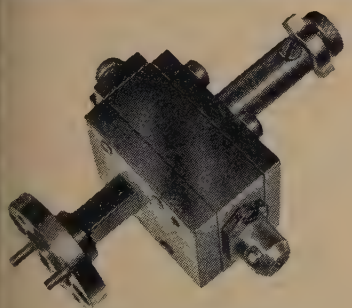

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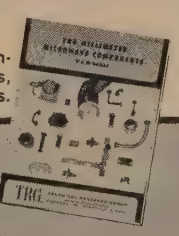

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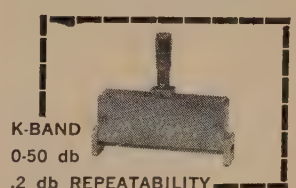

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Frequency range:	Center frequency between 30 MC and 300 MC
Bandwidth:	Up to 10% of center frequency
Gain:	Greater than 20 DB (function of freq. and BW)
Noise figure:	≤1 DB at 30 MC to <3 DB at 300 MC (function of freq. and BW)
Source impedance:	50 ohms
Output impedance:	50 ohms
Connectors: input	Type BNC, or N
output	Type BNC, or N
power	2 prong motor base receptacle
Power requirements:	115 VAC, 60 cps, 25 W
Dimensions:	19" L x 3½" H x 6½" D
Weight:	12¾ lbs.
Finish:	Gray enamel panel

For additional information write

Applied Research inc.

76 South Bayles Avenue, Port Washington, N. Y.

Book Review

(*Continued from page 20*)

There is, for example, very little said about plating te niques. Occasionally there is mention of the need or sirability of plating, for example, iron with copper, no discussion of how to achieve a vacuum tight bond tween the plate and the substrate.

Again, we feel that more might have been said ab machining techniques. Some data on copper are given, none on the refractory metals or on ceramics. Since machinists who have not been trained specially for field have had experience with these materials, informat on this problem would be useful.

Again, too, we find no reference to some of the ne techniques of pyrolytic deposition, heliarc welding, di sion bonding, and the like. Possibly, these are still too s cialized to particular areas to be given detailed coverage a general reference book, but we are inclined to think t should not have been ignored.

We also find the usual problem that dielectric inform tion on glasses and ceramics is quoted at 1 mc. Since th figures have little relation to the microwave propert their usefulness to microwave engineers is thereby limi

It is also a little odd to find a book on electron tube te niques that says so little about pumps, gauges and vacu systems in general. This is flattering if it happens beca the author feels that all engineers in the business hav fully adequate knowledge of vacuum engineering, but i doubtful if such a happy state of affairs exists.

Admittedly the addition of these and other exclu topics would have increased the size—and, no doubt, price—of the book. Certainly the author had to cut somewhere, omitting topics that are of considerable portance in certain areas. Nevertheless, we may wish t he had drawn the line a little differently.

Within the limits of its scope, however, the book mains an important and impressive addition to the sources of the tube designer. As a source of information many topics of vital concern to him, and as a review sources which he is not likely to find for himself, it is important work. Since it interprets these topics in te of the specific problems of tube design, and in the langu of the tube engineer, this information is readily useable people in this and related fields.

It should be an important resource to any engineer must seek the "best" way of doing things.

REPRINTS

Reprints of complete Technical Sections from back numbers of *the microwave journal* are available from the publisher at a cost of 25 cents per back number. Supplies of the following Technical Sectio reprints are currently out of stock: Vol. 1, No. 1 July/August, 1958; Vol. 1, No. 2, September/Oc tober, 1958; Vol. 2, No. 1, January, 1959; Vol. 2 No. 2, February, 1959.

New Literature

(*Continued from page 84*)

MICROWAVE FERRITES

Ferrites designed for the microwave device engineer are illustrated in a new fourteen page brochure, prepared by Solid State Research, Inc., Glendale California. The brochure not only describes a new line of low-loss ferrite materials having application in the S, C, X, K, and L-band regions for diversified devices such as isolators, rotators, phase shifters, switches, and circulators, but also presents valuable application information.

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—*mwj*—

WAVE GUIDE SEAL CONVERSION CHART

A new Wave Guide Conversion Chart for flange seals, recently issued by Parker Seal Company, Culver City, Cal., shows all wave band series and various seals produced by the Company to fit standard flanges.

The Chart also includes dimensions and other pertinent data useful for checking materials, sizes, etc. This Chart is available upon request.

Circle Reader Service Card 119

Industry News

(*Continued from page 60*)

MAGENHEIM JOINS C.E.C. AS MICROWAVE DIVISION HEAD

Bertram Magenheim has joined Control Electronics Co., Inc., Huntington Station, N.Y., as Microwave Division Head. In his new capacity, he will be responsible for the overall design, development and manufacture of all C.E.C. microwave components and instruments.

From 1957 until joining C.E.C. Magenheim was Senior Project Member of the technical staff at R.C.A. where, among his duties, he had responsibility for the advanced development of the Microwave Subsystem for a Long Haul High Capacity Microwave Radio Relay System. Prior to that, Magenheim was Microwave Signal Generator Group Leader at Polarad Electronics Corp., Long Island City, N.Y. From 1951 to 1955 he was a Microwave Section Head of FXR, Woodside, N.Y., and from 1950 to 1951 was an electrical engineer at Raytheon Mfg., Waltham, Mass.

—*mwj*—

(*Continued on page 88*)

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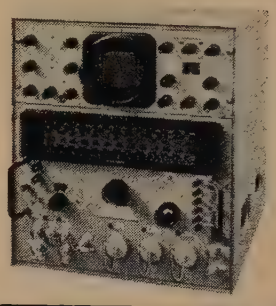

PANORAMIC'S SPA-4 SPECTRUM ANALYZER

MORE USEABLE SENSITIVITY

BAND	RF SENSITIVITY*
10 — 420 MC	—95 to —105 dbm
350 — 1000 MC	—90 to —100 dbm
910 — 2200 MC	—90 to —100 dbm
1980 — 4500 MC	—80 to — 90 dbm
4.5 — 10.88 KMC	—80 to — 95 dbm
10.88 — 18.0 KMC	—70 to — 90 dbm
18.0 — 26.4 KMC	—60 to — 85 dbm
26.4 — 44.0 KMC	—55 to — 85 dbm

*measured when signal and noise equal 2X noise

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OPPORTUNITIES IN UHF AND MICROWAVE RESEARCH AND DEVELOPMENT

Never before has such high priority been given to microwave research and development . . . never before have the opportunities been so great in this field for the qualified engineer and scientist.

The Research Center of the Bendix Aviation Corporation—The RESEARCH LABORATORIES DIVISION—is expanding its programs in the UHF and microwave field to create interesting and challenging positions for qualified personnel.

Technical openings are now available in the following fields:

ANTENNA RESEARCH in electronic scanning, log periodic anténnas, microwave optics.

MICROWAVE ENGINEERING—in ferrite devices, electronically controlled phase shifters, parametric amplifiers.

ELECTRON TUBE research in BWO and TWT from 1,000 to 150,000 mcs.

Investigate these opportunities *now*, where your technical competence and potentialities will receive full recognition in "Building Your Future with Bendix".

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Research Laboratories Division
SOUTHFIELD, MICHIGAN

Bendix
AVIATION CORPORATION

Industry News

(*Continued from page 87*)

WASHINGTON, D.C. OFFICE OPENED BY HAZELTINE

Hazeltine Corporation, one of the tion's defense contractors, has announ the opening of a new office in Washi ton, D.C.

According to W. A. MacDonald, cha man and president of the 36 year old el tronics firm, "The new office will bet enable Hazeltine to serve the country's fense needs by providing on-the-spot l son with the Government agencies sponsible for keeping America's defen strong."

Hazeltine and its subsidiaries are tive in the airborne radar, ground rad anti-submarine warfare, ground supp equipment, electronic display, data p cessing and computer, air traffic cont missile guidance and launching and id tification friend or foe fields.

In addition to its Washington off Hazeltine has headquarters in Little Ne Long Island, and facilities in nine ot Long Island communities. Other Ha tine engineering centers are located Indianapolis and Chicago, and a liai office is also maintained in Dayton, O

— m w j —

DOLAN JOINS MICROLAB

It was announced by Microlab, Livi ston, N.J., that Harry C. Dolan has b appointed sales manager.

Microlab is a manufacturer of mi wave coaxial components. The comp has specialized in providing off-the-s delivery of over 10,000 microwave c ponents.

Mr. Dolan's responsibilities include veloping a national field sales organ tion and overall sales administration. will assist in commercial planning, ministration, advertising and sales motion.

He is a graduate of Seton Hall Univer-ty, where he received a B.S. degree in 049, and is a member of the Institute Radio Engineers and the Armed Forces ommunications and Electronics Asso-iation.

Prior to joining Microlab, Mr. Dolan as employed by Frequency Standards, sbury Park, as sales manager.

—*mwj*—

JACKSON AT NEW POST FOR GABRIEL

The appointment of E. Paul Jackson as ashington marketing representative has en announced by J. B. Hamre, director Sales for the Gabriel Electronics Divi-n of The Gabriel Company.

Mr. Jackson will be responsible for rket development activities for the ashington, D.C. area and will maintain ces in Washington, D.C. Recently nager of Special Projects for Fairchild gine and Airplane Company, Mr. Jack-n is known in the electronics, aircraft missile industries.

Mr. Jackson attended the University of ltimore and Angola Technical Institute l holds memberships in the American dnance Association, Association of the S. Army, The Navy League and the tional Aviation Club.

—*mwj*—

SYMPOSIUM ON ELECTROMAGNETIC WINDOWS

Symposium on Electromagnetic Win-ws will be held June 20 through 22, 0, in the Ohio Union at The Ohio e University, Columbus, Ohio. The nary objective will be to expedite fu-e programs and to review the state he art for this branch of electromag-cs.

fficial invitations along with registra-instructions and programs will be led in May.

—*mwj*—

NEW HEADQUARTERS PLANNED FOR LOCKHEED ELECTRONICS

David F. Sanders, president of Lockheed Electronics Company, Plainfield, N.J., has announced the purchase of a 212-acre site near Princeton University for the future headquarters of the firm.

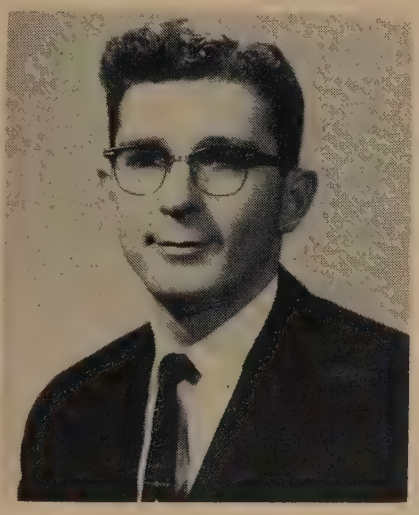
"Our new site fronts on U. S. Highway No. 1 in West Windsor Township near Princeton," he said. "It offers proximity to the research facilities of Princeton University and many of the leading private industrial laboratories and electronic development centers of the nation."

A master plan for developing the property will cover its use as company headquarters as well as providing room for expansion of the Military Systems-Stavid Division here. It will accommodate several new operating divisions now being formed within the organization.

Lockheed Electronics intends to develop the facility for the research, development and manufacture of electronic systems and subsystems for the military services.

—*mwj*—

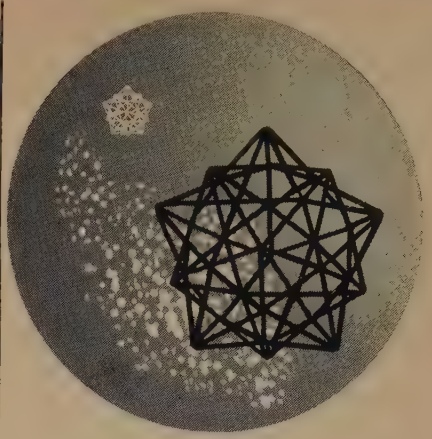
MALONEY ELECTED VICE-PRESIDENT AT PORTCHESTER INSTRUMENT CORP.



George Donald Maloney has been elected a vice president of the Portchester Instrument Corp., Port Chester, N.Y., and assumes the responsibility for all manufacturing operations. Mr. Maloney has been in charge of the electronic testing and quality control for the Company since 1956.

This follows a company policy to bring electronic engineering personnel into management positions. Portchester Instrument Corp. designs, develops and manufactures microwave components for link communications for the system manufacturers.

(*Continued on page 90*)



ENGINEERS
SCIENTISTS

FUTURISM in contemporary R&D

Radical departures from traditional forms of scientific investigation are the keynote of Republic Aviation's forward-looking programs in space exploration and upper atmosphere flight. In an environment that regards with skepticism the seeming validity of conventional conclusions, engineers and scientists seek below-the-surface solutions of problems... bypassing the superficial.

Expanding the scope and depth of present programs is Republic's recently completed $14 million Research and Development Center. Extensive facilities here are an invitation to professional men to realize the future by solving today's most perplexing problems.

• • • • • • • • • • • • • • • • • • •

SENIOR LEVEL OPENINGS EXIST IN THESE IMPORTANT AREAS:

Navigation & Guidance Systems / Radar Systems / Information Theory / Radio Astronomy / Solid State & Thermionic Devices / Microwave Circuitry & Components / Countermeasures / Digital Computer Development / Radome & Antenna Design / Receiver & Transmitter Design / Miniaturization-Transistorization / Radiation & Propagation *(RF, IR, UV)* / Telemetry-SSB Technique

Please forward resumes to:
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Technical Employment Manager,
Department 34 E

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Long Island, New York

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Nationally known research organization has an exceptional opportunity for an Electronic Engineer or Physicist with outstanding technical and administrative competence, to direct its broadly diversified research and development activities in the following areas:

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Special Test Equipment • Interference Evaluation

Antenna Development

As Microwave Research Supervisor you will be joining a staff of approximately 100 electronics research and development engineers with a growing reputation. Our environment is midway between academic and industrial research and offers an unusual opportunity to develop research programs of greatest appeal to you and your staff. You will receive a competitive salary plus liberal insurance and retirement benefits in addition to four weeks vacation after one full calendar year of service. Our location in a major midwestern city offers excellent cultural and recreational opportunities.

If you are an exceptionally qualified engineer with an advanced degree and 8 to 10 years of diversified microwave research experience who desires an unusual opportunity for professional advancement, send a complete resume, in confidence, to:

Box A-12

c/o the microwave journal

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Two outstanding opportunities exist with long established, nationally known manufacturer of electronic instruments.

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Both of these positions require knowledge of and experience in microwave theory and techniques, technical and scientific administration and planning.

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MANAGEMENT CONSULTANTS

420 LEXINGTON AVENUE, NEW YORK 17, N. Y.

Industry News

(*Continued from page 89*)

GALBRAITH AT NEW POST FO LOCKHEED

Russell C. Galbraith has been nam to the new post of vice president for ministration, Lockheed Electronics C Plainfield, N.J.

In making the announcement, Lockhe Electronics' president, D. F. Sanders, s Galbraith will be responsible for financ and legal matters, industrial relatio public relations and organizational pl ning.

"The formation of Lockheed Electron Co. and the creation of four diversif operating divisions requires executi with exceptional managerial skill and perience," Sanders added. "Mr. G braith's 25 years in industrial mana ment will be of great value in organiz the administrative end of our grow company."

Galbraith was formerly assistant g eral manager of the Lockheed Electron and Avionics Division, Los Angeles, C before the consolidation of that divis with the former Stavid Engineering, I into Lockheed Electronics Co. Prior that, he was director of financial ope tions for the California Division of Lo heed Aircraft Corp. and served in same capacity for the company's Geo Division, in Marietta, Georgia.

A graduate of the University of Mi gan with a B.A. degree in economics business administration, Galbraith i member of the Controllers Institute America and the National Association Accountants.

—*mwj*—

Opportunities at Hughes in

microwave research and development

Modern electronic systems demand a broad range of technical competence. The Hughes Microwave Laboratory has unusually extensive capabilities in the antenna, microwave component, and radome fields. Its activities are co-ordinated in a balanced program of fundamental research, development, design and production engineering.

ANTENNA RESEARCH—Included in current studies are: electronic scanning, its information transfer functions, and its relationship to system performance; surface waves and conformal surface antennas potentially useful on nose cones or low silhouette applications; and the theoretical aspects of transmission through small radomes.

ELECTRONICS RESEARCH—These investigations are concerned with basic phenomena such as amplification, harmonic generation, limiting and switching with ferromagnetic and dielectric materials, and superconduction in thin films at microwave frequencies.

MATERIALS RESEARCH—In the fields of Solid State Chemistry and Physics, studies are directed toward the synthesis and characterization of organic and inorganic compounds; new polymer systems; structural and electronic ceramics; and ferroelectric, ferrimagnetic and paramagnetic materials for electronic applications.

MICROWAVE ENGINEERING—the products of research are converted into advanced components, processes, and techniques for ultimate system application. Novel antennas, radomes, filters, and ferrite devices are being developed for the entire microwave and UHF spectra. New materials and processes are exploited for the production of ferrites and garnets, silicone plastics, ablative materials, high-temperature insulating and encapsulating materials, and electroluminescent panels. Research and engineering ideas are rapidly embodied in concrete forms through the facilities provided by a versatile design staff and a well-equipped shop.

Openings exist in each of the above areas. These positions offer excellent opportunities for qualified personnel in the fields of Physics, Chemistry and Engineering (Electrical—Microwave—Mechanical).

Please write: Mr. R. A. Martin, Supervisor, Scientific Employment

HUGHES ENGINEERING DIVISION, *Culver City 19, California*

HUGHES *the West's leader in advanced electronics*

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A. X-Band Reciprocal Ferrite Phase-Shifte Experimental Electronic Scanner

B. Close-up of Hughes Ferrite Amplifier

C. Apparatus for X-Raying Single Xtal Ferrites and Garnets

The Applied Physics Laboratory
The Johns Hopkins University

Microwave Engineers

SENIOR and JUNIOR LEVELS

for outstanding professional positions on technical staff

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The members of our technical staff work in an academic atmosphere conducive to creative thinking. We offer you an opportunity for theoretical as well as original applied research. You will work with the latest equipment and on assignments which will enable you to advance to the forefront of your chosen field. Your colleagues will include leaders in the microwave field.

Our modern laboratories are located in Howard County, Maryland, equidistant between Baltimore and Washington, D. C. Houses and apartments in all price ranges are readily available, and our location offers you a choice of city, suburban or country living.

For detailed information about these career opportunities, address your inquiry to:

Professional Staff Appointments
The Johns Hopkins University
The Applied Physics Laboratory
8651 Georgia Avenue, Silver Spring, Md.

SENIOR MICROWAVE ENGINEER

You will be given system responsibility for the development of new concepts in the generation, propagation and radiation of microwave power for heating, cooking and curing purposes, in numerous commercial and industrial applications. (Raytheon is one of the few electronics companies whose staff includes systems, advanced development, and design engineers in these fields.)

You must have a BSEE or equivalent and should have 8 years of broad design or advanced development experience in the microwave field in order to handle the planned assignments. (Experience in radar development, for instance, or DC power generators or magnetrons.) Since we're looking for an exceptional individual—who will be rewarded accordingly—the deciding factor will probably be your creativeness and ingenuity, as evidenced by: patent disclosures; significant publications; or descriptions of accomplishments not formalized by patents or publication.

MICROWAVE LICENSEE ENGINEER

You will serve as liaison between Raytheon and licensees, assisting in the design of microwave cooking units for these licensees' commercial ovens. This will involve working with the licensees' design engineers to solve such problems as heat, sanitary considerations, microwave distribution, wave modulation, insulation and cost reduction. You will also help translate licensees' suggestions into product improvements.

You should be a senior-level electronics engineer with a BSEE or equivalent and should have 5 years' applicable experience. Background in design of test equipment, high-power modulators, or commercial microwave equipment is especially useful, as is knowledge of magnetrons, underwriters' requirements and FCC regulations. Basically, we're looking for a top design and sales engineer (travel will be limited, however) so salary is commensurate —that is, excellent.

Both positions are in the suburban Boston area and offer attractive cultural, educational and recreational opportunities. Relocation assistance is available. Please phone collect (BIgelow 4-7500) or forward your detailed resume to Mr. Paul R. Alexander, Manager of Professional Personnel, Commercial Apparatus & Systems Division, Raytheon Company, Watertown, Massachusetts.

RAYTHEON COMPANY

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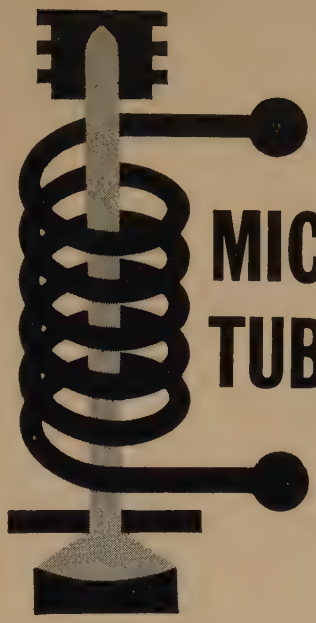

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You will be working for a large company but...

You will be working in a small group on the product of your choice—TWT's, Superpowered Klystrons, crossed field amplifiers, or other sophisticated microwave devices.

Choose research or design and development, whichever field interests you most.

The location is in the San Francisco Bay Area. Your children will belong to one of the nation's great elementary school systems. You, yourself, will be close to all the cultural activities of San Francisco, the Berkeley campus of the University of California, Stanford University, San Jose State College, and the University of Santa Clara.

Openings exist for Senior, Project and Junior Engineers. Junior Engineers need have no experience beyond their baccalaureate in E.E. or Physics.

We assist with relocation expenses. Interviews may be arranged by writing, or telephoning collect to:

Mr. Thomas B. Fike
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LITTON INDUSTRIES
Electron Tube Division
San Carlos, California

This "bazooka" type cannon of 1395 fired lead, lapidary and finned missiles. Their main disadvantage — practically impossible to aim or guide to its target. The missile was named after Henry VIII because he was considered a connoisseur of walking sticks which were often used to conceal weapons.

Today, as a vital part of one of the world's largest electronics companies, Raytheon's Missile Systems Division is making significant contributions to the art of missilry. The exciting new Pin Cushion Project for selective missile identification, the constantly advancing Navy's air-to-air SPARROW III and Army's HAWK are examples of their outstanding creative work.

We are seeking highly creative people to maintain Raytheon's leadership in this challenging field. For these people, Raytheon's Missile Systems Division creates a climate for talent — perhaps *your* talent.

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Please apply to Mr. W. F. O'Melia, Employment Manager, Bedford Laboratory, Missile Systems Division, Raytheon Company, Bedford, Mass.

19B

RAYTHEON MISSILE SYSTEMS DIVISION

...creates a climate for talent.

PRODUCT PLANNING THROUGH R & D

B. G. RYLAND
DIRECTOR of ENGINEERING
Microwave & Power Tube Division • Raytheon Co.
Waltham • Massachusetts

The most important problem facing many microwave tube manufacturers today is how to translate the millions of dollars they may now be spending on governmental R & D into profitable products five years hence. It is well known that cost plus contracts indeed present shaky ground upon which to build an enduring future or profit position. If we recognize that the microwave business has become increasingly dependent on government sponsored R & D, how should the manufacturer conduct his operation so as to insure a continuingly favorable profit position? It is the purpose of this discussion to outline some basic precepts in planning for profits and, further, point out some common practices which are in violation of these precepts.

What motivating force initiates the large R & D microwave component program today? Usually it is the need to fill a particular socket in a developmental military system. With this thought in mind, let us examine the sequence of events from time zero to successful product completion. Our example is based primarily on a microwave tube development process and certainly cannot cover the ramifications of all component development programs. The common denominator of planning R & D for profit, however, should be applicable to any component development program.

The bulk of microwave components development programs can be described in terms of a rather general temporal pattern. The first phase of the program covers the establishment of feasibility and practicality of the device. In this period, the work is directed toward the understanding of physical phenomena; then theorizing and confirming the theory by experiment until sufficient knowledge of the subject is obtained to permit extrapolating the idea into a useful device. Experiments certainly have a part in this phase of the program but the experimental device itself is rarely a saleable or manufacturable product. At the conclusion of this phase, though experimental work has been done to establish much marks, boundary conditions and to point up major problem areas which may limit the operation of the device. Specifications may or may not be revised at this time. In any case, work is next directed toward the actual product development.

Duration of the product development phase varies considerably depending upon the complexity of the product involved. In the microwave tube industry, the second phase may last for about a year and one half. The knowledge previously gained during the first phase is now utilized to design a device with rather specific characteristics in mind. Many of the decisions, which could not be made on the basis of previously available data, are now made on the basis of experimentation — this includes the construction of actual devices for evaluation of their characteristics, analysis and then redesign. This process is repeated until some of these sample devices exhibit characteristics so nearly approaching those desired that they may be supplied to the customers to be tested and evaluated. Successive samples should then come closer and closer to the specifications. Evaluation of study samples should indicate either the definition of the goals of the project, or a more precise specification of the capabilities of the device.

The advanced product development phase ends when a given number of samples show repeatable characteristics within the range of the specifications. Work is now directed toward quality controlled production in a phase which may require a year or more, including the modification of the physical design, the acquisition of tools, fixtures and training of personnel.

The whole cycle covering the three phases, (1) research, (2) advance development, and (3) manufacturing may typically have consumed three to four years between conception of the idea and the start of full scale profitable production. Only in rare cases can this time schedule be appreciably compressed; and, certainly, the lack of diligence or sufficient funding in any one of the phases can measurably add to the time required.

Here is critical point number one. Failure to recognize the time scales of the typical program is, perhaps, the most common mistake made in present day business planning. Attempts to do in the period of a few months what should have been done as a well planned program over one to three years, more often results in a waste of money and effort as well as a lack of satisfactory results. Profits may also be lost in the production phase while attempting to manufacture a poorly designed product. One may even conjecture that this course of action was taken knowingly perhaps on the rationalization that such long range plans are alright for someone else but in this case "we can take a short-cut." In rare instances such "short-cuts" work. More often than not the "short-cut" decision is based on the manager's unwillingness to face up to the risk involved in long term product planning.

In some instances failure to establish such plans is deliberate. We have all seen the expert who is brought in as head of a group ostensibly to "straighten things out," to increase profits, etc. His first desire is to show a profit. This he does, after his first year, by a simple,

easy straightforward technique — quit spending money on future products. The Board of Directors cannot know this — all they see is John Smith as a dynamic, hard hitting, aggressive manager who now appears as black ink on the profit and loss statement. He has "straightened things out." The Board of Directors are, in fact, so happy about the whole thing that after two or three years John Smith is promoted out of his job and leaves an impossible void for his luckless successor to fill — if he can. Man number two is doomed to failure even before he starts.

There are other errors in planning overall product development programs which can contribute to failure. One erroneous concept is the "one-man band." In the business which evolves around and depends upon the technical capabilities of a single individual, the normal growth of the business eventually dilutes the contributions of this man. Without the development of a sound organizational back-up, the efforts of this individual are spread thin over the many products and/or problems involved in business growth until, ultimately, his contribution to an individual product line or program is so small as to be insufficient to foresee or prevent disaster. Product development for a company of increasing stature must become a team effort with many individuals contributing their particular skills and abilities to the overall program. Further, a workable division of responsibility must be established. Such a team effort will afford protection against the professional recruiter who can, at one blow, remove the star performer and the company's reason for existence. Cautious expansion and careful grooming of a support team is the only solution.

A similar, erroneous concept is the one of the "one-idea business." In this situation, the business is devoted to a single significant contribution and an effort is made to exploit this contribution to its maximum without development of the diversity of the products or ideas which would put the business on a firm foundation. Too often this results in an organization trying to sell its single concept for the sake of survival, rather than in the interest of the customer and business in general. There is nothing wrong with a proprietary product; however, most of such products do not remain proprietary very long. Survival in a business as competitive as the microwave industry requires an open-mindedness and awareness of the development and contribution of others, and cannot be achieved by devotion to a single concept which may fit the needs of only a limited group or period of time.

Other failures in the field of product planning can result from the normal conflict between the businessman and the scientist. The conflict arises largely from a misunderstanding on the part of the scientist and the businessman of the contributions and problems of the other. The scientist tends to feel that business decisions and procedures are vastly easier to understand than unraveling the scientific complexities of the material world. Consequently, he often wanders naively into business decisions of serious financial implication.

The businessman, however, may underestimate the abilities of the scientist in understanding the economic ramifications of the businessman's ideas. The businessman may often be guilty of a guarded ignorance of exactly what the scientist is trying to develop. Too often there is a tendency on the part of both types of in viduals to move a problem entirely within their o domain; hence, a failure to recognize that intellige decisions can be evolved only by a mutual exchange ideas and a consideration of all possible data availa for the decision-making process.

The major role played by the government, becau of the military implications of many of the products the microwave industry, adds additional hazards sensible product planning. There is a strong temp tion to believe that, since the government will supp research and development activities in a great ma areas, a company can be set up which will function o with this type of support for its product developme and yet evolve a profitable long-term product line. T can lead to the misconception that an established search and development laboratory can (1) pay its o way using government R & D funds; (2) simultaneou provide a continuous flow of products to manufact ing; (3) meanwhile advancing the state of the art the microwave field, and (4) at the same time, keep hand a highly experienced group of scientists who willing, and even eager, to apply their efforts to stric hardware programs as well as to pure and applied search. Such thinking fails to take many things i consideration such as the controls placed on governm R & D spending, where a modest fixed fee repres the ultimate in return; whereas additional expenditu on capital equipment, or even minor underestimates the technical difficulties of the program, can add su ciently to the cost of the program to consume the provided and may result in a net loss. The other ma problem in government R & D support, of course, the directing of the program toward the fulfillment o specific military need rather than the development o product with a more universal market. It should recognized that products which become the most pro able in production are those which are produced fixed-price business and which include substan amounts of proprietary contributions to their desi Consequently, long-term profitable production dema a sensible product planning and development progr not necessarily dependent on government requireme

To summarize the sound business precepts establis here we may make the following observations.

Successful planning for profits through Research a Development requires:

1. Realistic consideration of the normal time cy involved from R & D to manufacturing.

2. A strong product planning and market anal activity to augment a forward-looking scientific tea

3. A sound, mutual understanding between the b ness and scientific groups in the organization to ef maximum return on the engineering effort.

4. The avoidance of the "one-man band" type operation as well as the "one-idea" product.

5. Recognition of the need for fixed price sales w sufficient return to support R & D effort and fut product development.

Finally, one needs to understand completely that g ernment development programs, with millions of C dollars to spend, will never be a substitute for the l hard living involved in a competitive and dyna components industry.

For unmatched reliability... BOMAC BEACON MAGNETRONS

Life — up to 500 hours guaranteed — over 3000 hours reported
Frequency stability — less than 2 Mc drift per 100 hours (C band)
Power stability — drop of less than 1 db per 1000 hours of constant voltage input
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Shock — withstands 100 g's (6 millisecond duration)
Lightweight — 7 to 10 oz.
Miniaturized
Tunable over a broad band

Band	Tube Type	Fixed Freq. or Tunable	Frequency Range Mc	Min. Peak Power Watts	Outptut Mates With
C	BL-212	Tunable	5400-5900	100	UG699/U
C	BL-243	Tunable	5400-5900	200	UG699/U
C	BL-242	Tunable	5400-5900	400	N
C	BLM-022	Tunable	5400-5900	500	TNC
C	BLM-026	Tunable	5400-4900	500	TNC
C	BLM-020	Tunable	5400-5900	700	TNC
C	BL-245	Tunable	5400-5900	900	TNC
C	BL-250	Tunable	5400-5900	150	TNC
X	BLM-003	Tunable	9000-9500	150	TNC
X	BLM-014	Tunable	8500-9000	150	TNC
X	BLM-012	Tunable	8900-9400	1000	TNC
X	BLM-021	Tunable	8900-9400	1000	UG40A/U
X	BLM-024	Tunable	9300-9500	150	TNC

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Creative Microwave Technology

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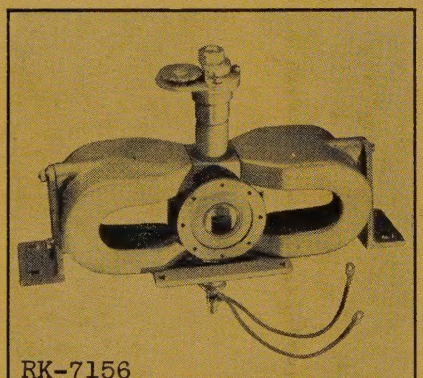
NEW RAYTHEON MAGNETRONS FOR A WIDE RANGE OF APPLICATIONS

Designed for C-band systems requiring tunability, the RK-7156 magnetron has a minimum peak power output rating of 250 kilowatts over a frequency range of 5,450 to 5,825 megacycles. Applications include a flight-tested, revolutionary airborne weather radar system. The RK-7156 is in quantity production.

Circle Reader Service Card 63



RK-7156

* * *

X-band magnetron for airborne search radar provides one megawatt minimum peak power and 875 watts average power within a frequency range of 9,340 to 9,440 Mc. Designated QK-624, this pulsed-type tube is liquid cooled and should give at least 1,000 hours of reliable service.

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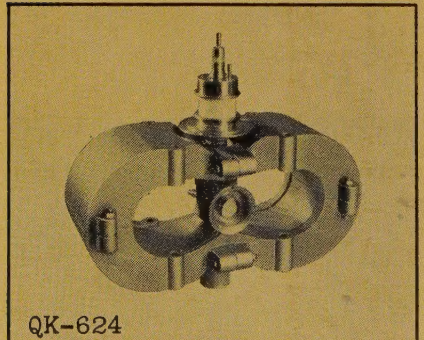

QK-624

* * *

For ground-based and airborne radar systems, the RK-7529 magnetron provides a 2.0 microsecond pulse of 3.5 megawatts minimum peak power over 2,700 to 2,850 Mc. This liquid-cooled tube is interchangeable with other fixed-frequency S-band tubes operating at similar power levels.

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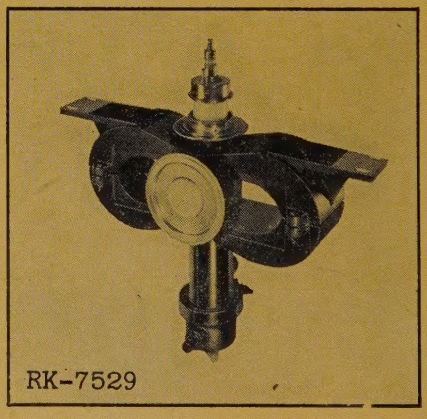

RK-7529

* * *

A one kilowatt beacon magnetron, the RK-7578 weighs only 14 ozs., yet will withstand vibrations of 15 G's at 20 to 2,000 cycles and shock up to 100 G's. It is mechanically tunable an covers the 5,400 to 5,90 Mc range.

RK-7578

Circle Reader Service Card 66

* * *

Developed to withstand extreme environmental conditions, the RK-7449 magnetron is a lightweight, compact tube with a minimum pea power output of 45 kilowatt at the operating frequenc of 24 kmc. The RK-7449 i required to withstand re peated shocks of 50G. Stab operation is guaranteed vibration frequencies up 2,000 c.p.s. with 30G a plied.

RK-7449

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